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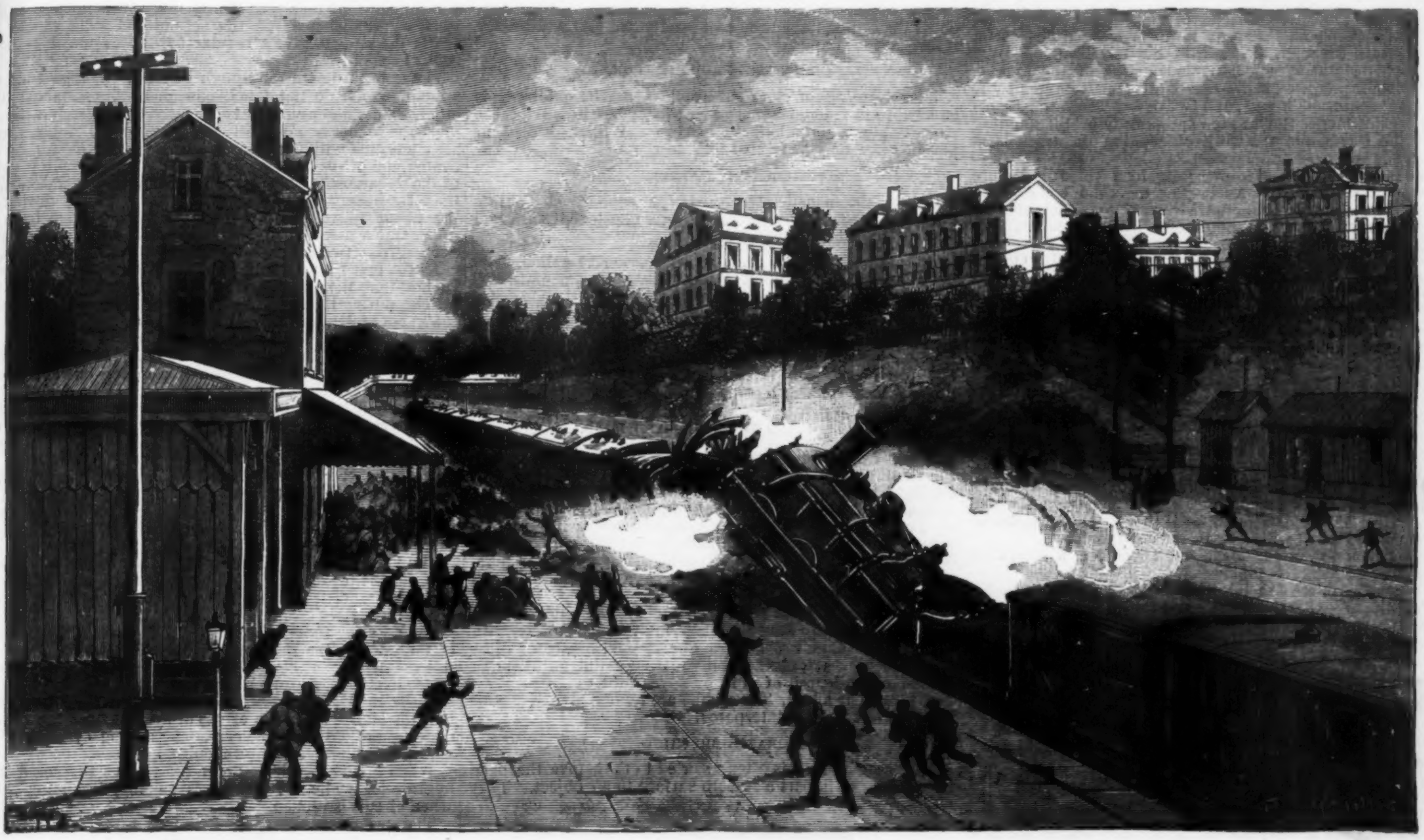

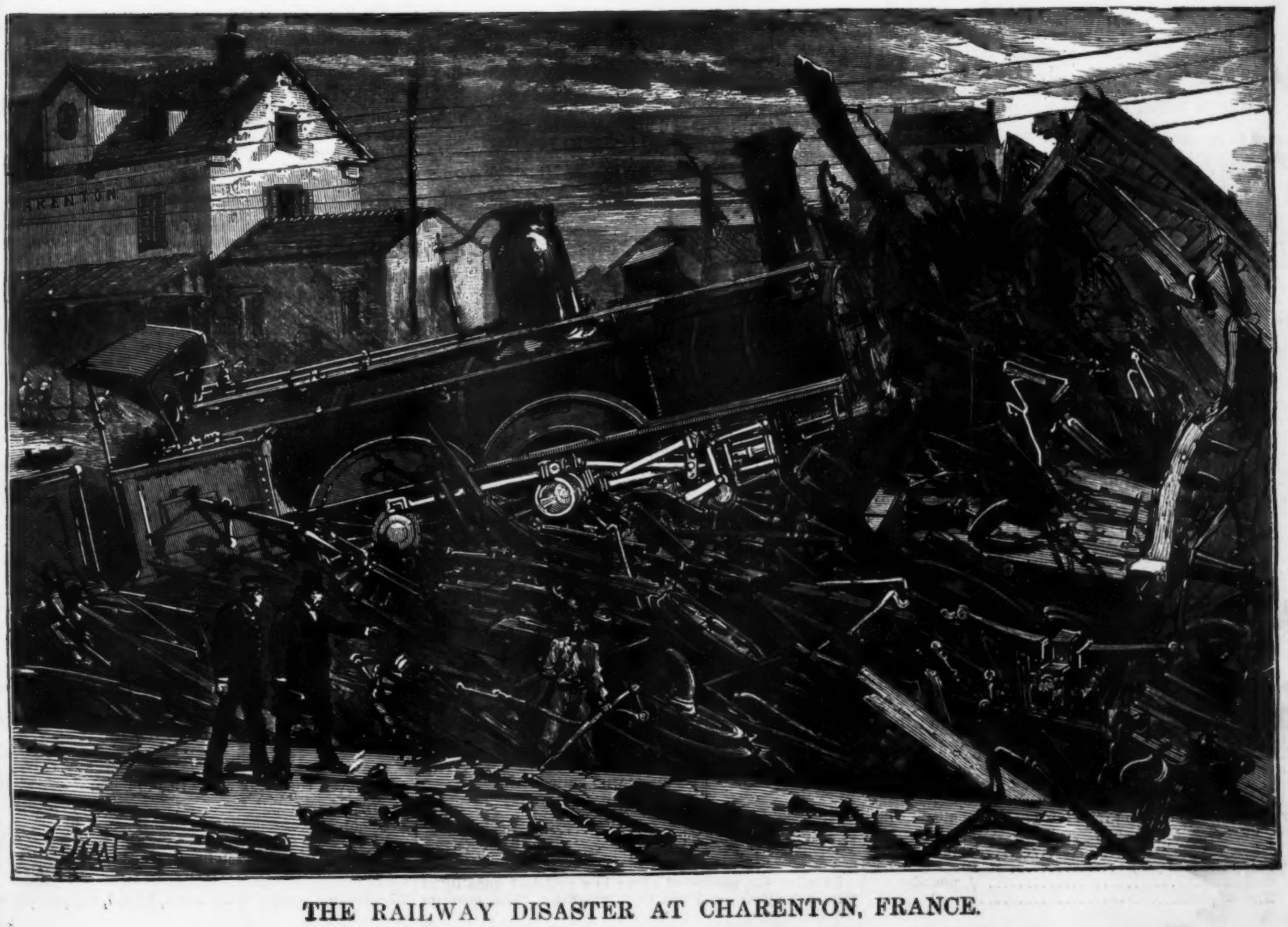

THE RAILWAY DISASTER AT CHARENTON, FRANCE.

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THE terrible catastrophe of September 6, 1881, at Charenton Station, Lyons Railway, still possesses a melancholy interest.

Way train No. 584 had just arrived at the station about twenty minutes behind time. The seven or eight cars of which it was made up, and especially the two that are usually filled with merchandise, were crowded with passengers. Suddenly, lightning express No. 10 from Marseilles was signaled, coming at full speed on the same track. The sharp bend that the track makes near the place of accident prevented its being seen in time. The alarm was given, the way train tried to start, and the express train endeavored to stop—but it was too late! A fearful crash ensued, the locomotive of the express train having reached the way train and completely smashed up the last two cars of the latter, burying more than forty passengers beneath the *débris*. The scene of horror that followed may well be imagined—it is indescribable. Broken windows, bent wheels, pieces of seats, here and there bits of flesh sticking to the wood-work of the cars, articles of clothing in tatters and covered with blood, all went to form a horrible-looking mass; while over all, like a wild beast holding his prey within his clutches, stood the locomotive of the express train, itself half wrecked. Our engraving represents the place of accident as it appeared two hours after the occurrence. The locomotive of the express train is still standing amid the *débris*, and the work of clearing the track is in progress.

The final result is well known; eighteen killed and more than twenty wounded. As fast as the dead bodies were taken from the ruins they were carried to a neighboring shed, from whence, after photographs had been taken, they were transported to the morgue, or placed on biers and given up to relatives to be taken home for burial. One of the saddest features of the accident was the death of a portion of a musical society from Ferte-Alais, which was on its way, full of joy and bright hopes, to take part in the international contest in England.

The astonishing power of the momentum of a first class locomotive when under headway is graphically illustrated by our engravings.

ELECTRO-METALLURGY.

CLEANSING AND PREPARING OBJECTS FOR ELECTROPLATING.

THE first and most important operation in the electro-deposition of one metal upon another is to effect a thorough chemical cleansing of the surface of the metal upon which the coating is to be deposited, for if this is not accomplished the deposited metal will not adhere to the surface.

In cleansing, different metals usually require a somewhat different treatment.

The surface of most metals when clean soon become coated with a film of oxide when exposed to the air, especially when the surface exposed is wet, and to avoid this it is usually necessary to proceed with the plating immediately after cleansing.

Before proceeding to cleanse the articles they are usually "trussed" with copper wire to avoid the necessity of handling them during the operation or afterward, until the plating is finished. A very slight contact with the hand is often sufficient to make a second cleansing necessary.

If the article to be plated presents a smooth finished or polished surface the deposit will be "bright." If, on the contrary, the surface is rough or unpolished the deposit will ordinarily have a dead luster. If left too long in the acid dips used in cleansing, a polished surface is apt to have its finish deadened.

No interval should be allowed between the various operations of cleansing.

CLEANSING COPPER AND COPPER ALLOYS.

Potash, caustic	1 pound.
Water, soft	1 gallon.

Heat nearly to boiling in a cast iron pot provided with a cover.

Brush to remove any loosely adhering foreign matters, truss, and suspend for a time in the hot lye; usually a few minutes will suffice if the article is not heavily lacquered. If any of its parts are joined with solder it should not be allowed to remain too long immersed, as the caustic liquid attacks solders and their solution blackens copper. On removing rinse thoroughly in running water.

If the articles are much oxidized, pickle in a bath composed of—

Water	1 gallon,
Sulphuric acid	1 pint,

until the darker portion is removed. Rinse in running water and dip in the following solution:

Water, soft	1 gallon.
Cyanide of potassium, common	8 ounces.

Remove from the bath, and quickly go over every part with a brush and fine pumice stone moistened with the cyanide solution. Some electroplaters prefer to give the articles a preliminary "brightening dip" in nitric acid, or a mixture of nitric and sulphuric acids and salt, followed by rinsing in water, but the cyanide, aided by the mechanical action of the pumice and brush, does very well without it in most cases. After the scouring dip the work momentarily in the cyanide solution, rinse quickly in running water, and transfer immediately to the plating bath.

Where the article is to receive a deposit of gold or silver its surface is usually softened by slightly amalgamating it with mercury, to insure perfect adhesion of the deposited metal.

The amalgamating is performed by dipping the article, after the cyanide scouring operation, for a few seconds in a solution of—

Mercuric nitrate	¼ ounce.
Sulphuric acid	¼ "
Water	1 gallon.

Stir until the solution becomes clear before using. Rinse the work quickly on coming from the mercury dip, and transfer to the plating solution.

The acid, cyanide, and mercury dips may be kept in glass or stoneware jars (avoid jars with lead glazing) provided with covers to prevent evaporation.

A "dead luster" is imparted to articles of copper or copper alloy by dipping them for a few minutes in a bath composed of

Nitric acid (36°)	20 pounds.
Sulphuric acid (66°)	10 "
Salt	$\frac{1}{16}$ pound.
Zinc sulphate	$\frac{1}{16}$ "

Mix the acids gradually, add the zinc salt, then the salt, a little at a time (out-of-doors to avoid the acid vapors), stir well together, and let it get cold before using. Rinse thoroughly, and pass through the cyanide before putting in the plating bath.

CLEANSING CAST IRON.

Cast iron is freed from grease, etc., by dipping in hot alkali solution used for a similar purpose with copper, and after rinsing thoroughly is pickled in water containing about one per cent of sulphuric acid for several hours; then rinsed in water and scoured with fine sharp sand or pumice and a fiber brush. It is then rinsed and returned to the acid pickle for a short time, rinsed again, and put into the plating bath directly. If more than one per cent of acid is used in the pickle the time of immersion must be shortened, otherwise the iron will be deeply corroded, and the carbon which the metal contains, and which is not affected by the acid, will not yield without a great deal of labor to the sand and brush.

Cast iron does not gild or silver well by direct deposit. Copper or bronze deposits are better, though not perfect; but if the iron is tinned the coat is adherent and will readily receive the other metals.

CLEANSING WROUGHT IRON.

The cleansing of wrought iron, if much oxidized, is effected in the same manner as cast iron; but it will bear a stronger pickle and a longer exposure. Whitened, filed, or polished iron may be treated like steel.

CLEANSING STEEL.

Dip in the caustic lye used for copper, etc., rinse thoroughly, scour with pumice powder moistened, rinse, and pass through the following dip:

Water	1 gallon.
Hydrochloric acid	4 pounds.

Rinse quickly (but thoroughly) and plunge in the bath.

Clean wrought iron and steel gild well without an intermediary coating in hot electro-gilding baths. It is difficult to obtain an adherent coating of silver on these metals without interposing an intermediate coating of copper or brass, which renders the further operation of silver plating easy.

CLEANSING ZINC, TIN, AND LEAD.

Zinc is cleansed by dipping for a few moments only (as the alkali quickly attacks the metal) in the hot potash lye, rinsing, and dipping into water containing about ten per cent of sulphuric acid for a few minutes. Rinse in plenty of hot water, and, if necessary, scour with pumice stone powder and a stiff brush, moistened with a weak cyanide solution, or scratch brush. This last operation is especially useful when parts have been united with tin solder.

Tin, lead, and the alloys of these metals are more difficult to cleanse perfectly than zinc or iron. Scour rapidly with the hot potash and brush, rinse quickly and brush, or dress with a piece of soft clean wood. It is very difficult to obtain a satisfactory deposit of gold or silver directly upon these metals or their alloys. The results are much better if a coating of pure copper is interposed.

SCRATCH-BRUSHING.

The scratch-brush is often resorted to to remove the dead luster on or to impart a smooth surface to an object. They

are usually made of brass or steel wire, and of a variety of shapes to suit the object. Some of the forms are shown in the figure.

The wheel brushes are used on the lathe, the objects being manipulated in contact with the rapidly revolving brush. The brush is usually kept moistened by a small stream of water while in use.

SILVER DEPOSITS.

For electro-silver plating the double salt of silver and potassium cyanide is almost universally employed. The baths are used either hot or cold. The latter method is generally adopted for articles which require great solidity. The hot process is used for small articles, and is preferable for steel, iron, zinc, lead, and tin, which have been previously electro-coppered. The hot baths are generally kept in enameled cast iron kettles, and the articles are either suspended or moved constantly about in them. A somewhat energetic current is needed, especially when the articles are moved about in order to operate rapidly. A gray or black deposit indicates too strong a current, and when the surface becomes covered with bubbles of gas the same thing is indicated. The anodes are plates of silver or heavy silver foil. The wooden tanks for the cold baths are similar to those used in plating with copper and nickel, but should be very thoroughly coated on the inside with gutta percha

THE BATH.

Water (soft)	1 gallon.
Cyanide of potassium (pure)	8 ounces.
Nitrate of silver	5¼ "

Dissolve the nitrate of silver in a sufficient quantity of pure water (soft), and add to it gradually, with constant stirring, hydrocyanic (prussic) acid until all the silver has been precipitated as cyanide, which may be known by the formation of no cloud in a portion of the clear liquid when a drop of the acid is added to it—avoid adding an excess of the acid. Throw the precipitate upon a fine cotton cloth filter, and as the liquid runs through wash the precipitate on the cloth several times with pure water. Dissolve the cyanide of potassium in the water, and stir in the cyanide of silver carefully removed from the cloth. If it does not dissolve in the liquid entirely, add more cyanide of potassium until it does, stirring continually. Let the impurities settle, and the bath is ready for use. Many electroplaters use a preliminary or silver "whitening" bath, which is the same composition, but contains less silver, more cyanide, and is worked with a somewhat stronger current.

The cleaned article in some cases is first dipped for a few moments in a solution of nitrate of mercury, one ounce in one gallon of water, and then in the whitening bath for a few minutes, and after brushing is transferred to the silver bath proper.

The vessels containing the cold bath are sufficiently high to allow about four inches of liquid above the immersed objects, whose distance from the bottom and sides should be nearly the same to give a regular deposit of metal at both ends of the object.

The upper ledge of the trough carries two brass rods all around, which do not touch one another, one above the other, so that other metallic rods placed transversely will rest upon the higher or lower series of rods only. The upper rods are connected with the zinc, the lower with the carbon or copper end of the battery, or with the corresponding poles of the dynamo-electric machine. The transverse rods resting upon the lower set support the silver anodes; those resting on the upper set, the work. The work suspended from an upper transverse is placed so as to face two anodes suspended from two lower transverse rods.

As the lower layers of the bath are apt to become denser (richer) than the upper, it is often necessary to reverse the articles during the operation to obtain a perfectly uniform thickness of deposit. For the same purpose small articles should be kept in motion as much as possible.

The deposit is finer and denser if obtained with a weak battery and long exposure than if a strong current is employed. A sufficient quantity of silver may be deposited in three or four hours, but it will be of much finer quality and more easily burnished if the work is left in the bath for twelve or fifteen hours with a few cells of battery.

When the articles, especially coppered iron, etc., have acquired a coherent film of silver, they are sometimes removed from the bath and thoroughly scratch-brushed, cleansed in alcohol, or preferably in a hot silvering bath, thence again passed through the mercurial solution and finished in the cold plating bath.

The first scratch-brushing, which is not always necessary, obviates the tendency of certain alloys to assume a crystalline appearance and corrects the imperfections of the cleansing in process.

Should the anodes become black during the passage of the current the solution contains too little cyanide. In this the deposit is adherent, but too slow; and the bath loses more silver than it can gain from the anodes.

If the anodes remain white during the passage of the current the bath contains an excess of cyanide, and the deposit does not properly adhere; correct by adding cyanide of silver until it dissolves with difficulty.

When in good working order the anodes present a gray appearance while the current is passing, becoming white when circuit is broken.

The specific gravity of the bath may vary from 5° to 15° Baumé's hydrometer and still furnish good results.

Electro-silvering baths do not generally work so well when freshly prepared. If properly used and cared for they improve by age. At first the deposit is often granulated bluish or yellowish.

It is customary to mix portions of an old bath with a freshly prepared one. Some platers introduce small quantities of ammonia instead to age the liquid.

Bisulphide of carbon in small quantities imparts a bright luster to plated articles. An ounce of the bisulphide is put into a pint bottle filled with a strong solution of the cyanide of potassium and silver, briskly shaken, and a few drops of this liquid poured into the bath occasionally until the work appears sufficiently bright. An excess of bisulphide must, however, be avoided, as it will spoil the bath.

What has been said about the arrangement of battery in articles of nickel and brass plating will also apply here. (See p. 153, vol. xliii., and 4, current volume, SCI. AM.)

GOLD DEPOSITS.

In the practice of electroplating with gold the bath employed is usually heated, as the deposits obtained in such a bath are more homogeneous, tenacious, and durable, and of a better color, besides which recommendation a greater quantity of the metal may be deposited satisfactorily from it in a given time than from a cold bath.

Owing to the cost of the metal to be deposited very large surfaces are rarely required to be electroplated, and as these baths become worn out and must be replaced by fresh solutions after a short time, they are usually, as a matter of economy and convenience, used in as small a vessel as the circumstances will admit of. These vessels may be of glass, porcelain, or porcelain-enameled iron. The latter serve the purpose admirably (if the enamel is good). They should be heated over the water bath or by means of steam.

The same bath does not answer very well for all metals—either the bath must be modified to suit the metal or the latter must be previously coated with another metal to suit the conditions. Gold deposits are obtained with the greatest facility upon silver or copper, their rich alloys, or other metals coated with them. With these a hot bath (at about 170° F.) and a moderately strong current give good results. With alloys, such as German silver, the best results are obtained with a weak bath, barely warm. Steel and iron, when not coated with copper, require an intense current and a very hot bath. Lead, zinc, tin, antimony, and bismuth alloys of, or containing much of these, are preferably coated with copper before electro-gilding.

HOT BATHS.

For silver, copper, or alloys rich in these:

Distilled water	1	gallon.
Phosphate of soda, cryst.	9¼	ounces.
Bisulphite of soda	1¼	"
Cyanide of potassium, pure	¼	"
Gold chloride	160	grains.

Dissolve in a portion of the water, heated, the phosphate of

soda. Dissolve in another portion of the water the bisulphite of soda and cyanide of potassium.

Dissolve the gold chloride in the remaining water, stir the solution slowly into the cold phosphate of soda solution, and finally add the solution of cyanide and bisulphite. The bath, now ready for use, should be colorless.

The cost of this bath is about $5 a gallon, and the metal can be deposited from it profitably at $2 per dwt. Used at a temperature of from 120° to 175° Fah.

BATH FOR IRON AND STEEL—UNCOATED.

Distilled water	1	gallon.
Phosphate of soda, cryst	7 5/16	ounces.
Bisulphite of soda	2	"
Cyanide of potassium, pure	½	drachm.
Gold chloride	160	grains.

Dissolve as before. Heat to 175° or 180° Fah. Pass the second metal through the hot potash, then through dilute muriatic acid (acid 1, water 15), brush, and connect at once. Requires a very intense current at first.

The following baths work well with bronze and brass, but are not suited for direct gilding on iron or steel:

Distilled water	1	gallon.
Phosphate of soda, cryst	6⅞	ounces.
Bisulphite of soda	1¾	"
Bicarbonate of potash	¾	"
Caustic soda	¾	"
Cyanide of potassium, pure	½	"
Gold chloride	¾	"

Dissolve all together, except the gold chloride, in the hot water; filter, cool, and gradually stir in the gold chloride dissolved in a little water. Heat from 120° to 140° Fah. for use. It requires an intense current.

Distilled water	1	gallon.
Ferrocyanide of potassium	5¼	ounces.
Carbonate of potash, pure	1¼	"
Sal ammoniac	¾	"
Gold chloride	¾	"

Dissolve as in the last, boil for half an hour, replace the evaporated water, and the bath is ready for use.

Distilled water	1	gallon.
Cyanide of potassium	2¼	ounces.
Gold chloride	1	"

Dissolve the gold chloride in the water, then add the cyanide, and stir until solution is complete.

Baths of this kind are commonly used, and with little regard to temperature. They are simple in preparation, but are, unfortunately, not very uniform in their working, ungilding one part while another is gilding, and producing a variety of colors, especially when freshly prepared. They improve by use, however.

COLD ELECTRO-GILDING BATH.

Water, distilled	1	gallon.
Potassium cyanide, pure	3¼	ounces.
Gold chloride	3 1/16	"

Dissolve the cyanide in a part of the water, then gradually add the gold chloride dissolved in the remainder. Boil for half an hour before using. (Use cold.)

The cold bath is kept in a gutta percha lined, wooden, or (if small) porcelain tank arranged as for brass plating. The anodes are thin plates of laminated gold, wholly suspended in the liquid (while in use) by means of platinum wires, from clean brass rods joined to the copper or carbon pole of the battery, the rods supporting the work being in connection with the zinc. When in proper working order the color of the deposit is yellow. If the deposit becomes black or darkred, add more cyanide (dissolved in water) to the bath, or use a weaker current.

If the cyanide is in excess the plating will proceed very slowly or not at all; or, as sometimes happens, articles already gilded will lose their gold. In such a case add a little more gold chloride or increase the intensity of the current.

Cold electro-gilding must be done slowly, and requires a great deal of attention to secure good work. The articles must be frequently examined to detect irregular deposits or dark spots (which must be scratch-brushed and returned). It is also frequently necessary to add to or remove an element from the battery, especially when adding or taking work from the bath. With too much intensity of current the deposit is black or red; if too weak those portions opposite the anode only get covered. In coating German silver it is necessary to use a weak bath and a small exposure of anode. The best results with this alloy are obtained when the bath is slightly warmed.

MANAGEMENT OF THE HOT BATH.

The articles should be kept in agitation while in the bath. They should be placed in connection with the battery before or immediately upon entering the bath. A foil or wire of platinum is in many cases preferable to a soluble gold anode when electro-gilding by aid of heat. It suffers no alteration in the liquid, and by its manipulation the color of the deposit may be materially altered. When it is removed so as to expose only a small surface in the bath a pale yellowish deposit may be obtained; when the immersion is greater, a clear yellow; with a still greater exposure, a red gold color. The strength of the hot baths may be maintained by successive additions of gold chloride with a proper proportion of the other salts and water; but it is preferable to wear out the bath entirely and prepare a new one, as it soon becomes contaminated with copper or silver if much of these metals have been gilt in it. In a nearly exhausted bath containing dissolved copper the electro deposit will be what is called "red gold;" if it contains an excess of silver a "green gold" deposit will result. The gold and copper or gold and silver are deposited together as an alloy, the color of which depends upon the relative proportion of the metals, battery strength, etc.

Dead luster gilding is produced by the slow deposition of a considerable quantity of gold, by giving the metallic surface a dead luster before gilding (by means of acids), by first preparing a coating of frosted silver or by depositing the gold upon a heavy copper deposit produced with a weak current in a bath of copper sulphate.

In order to secure a good deposit of gold it is absolutely necessary that the work should be perfectly freed from any trace of oxide, grease, oil, or other impurity. Articles of copper and brass may be cleansed by first immersing them in a strong boiling solution of caustic potash or soda, and, after rinsing, dipping momentarily in nitric acid and immediately rinsing, or scouring with pumice stone moistened with a strong solution of cyanide of potassium in water.

Other metals require a somewhat different treatment, which we will have occasion to refer to in a subsequent article.

The bichromate battery is commonly used in connection with hot electro-gilding baths. See article on nickel-plating, p. 153, No. 10, vol. xliii., SCI. AM.

As gold chloride procured in the market cannot always be depended on for purity and strength, it is preferable to purchase the gold and make the chloride. A pure gold chloride may be prepared as follows:

Put coin gold, in small pieces, into a glass flask with about five times its weight of aqua regia (nitric acid 1, hydrochloric acid 3), and heat gently, with small additions of aqua regia if necessary, until the gold is dissolved and the silver remains behind as white chloride. Let it settle, decant the clear solution, wash the residue several times with water, adding the washings to the gold solution. Evaporate off excess of the acids in a porcelain dish over a water bath (nearly to dryness). Dilute with ten parts of water, and gradually add a strong aqueous solution (filtered) of sulphate of iron. Let stand until the dark powder (gold) settles; gently decant the liquid, wash the gold with hot water, and redissolve it in a small quantity of warm aqua regia and evaporate the solution, with constant stirring, to dryness in a porcelain dish over the water bath. One ounce of pure gold equals about 1 1/16 ounces of this chloride.

NICKEL PLATING—THE PLATING BATH.

The nickel salts commonly used are the nickel ammonium sulphate (called double sulphate) and the corresponding chloride. Other salts, such as the nickel potassium cyanide, the acetate and sulphate, have been used, but not so successfully as these.

The double sulphate bath may be prepared by dissolving three-fourths of a pound of the salt in each gallon of water (soft). The salt costs about sixty-five cents a pound, and is generally considered the best for this purpose. It should be kept neutral and up to about six degrees of hydrometer.

The double chloride bath requires about four ounces of the salt per gallon, and works better slightly acid, the tendency in working being toward alkalinity.

The bath should be filtered when freshly prepared, and should be kept in a separate room, or at least away from the apartment in which the buffing or polishing is performed, to avoid contamination by dust as much as possible. Exposed to the air the bath (the water) evaporates, and the water thus lost must be replaced from time to time. To retard this and keep out dust as much as possible, it is well to cover the bath when not in use. Its surface should be skimmed occasionally, and it should be frequently mixed together to preserve a uniform degree of strength.

The tank or vessel in which the bath is contained is usually constructed of smooth two inch white pine stuff, grooved and well bolted together, and coated on the inside with good asphaltum, applied in the melted state.

Instead of this form a clean tub or a half barrel or hogshead, with an extra hoop, may be used, though from the shape of such a vessel there is necessarily much waste space to be filled with useless liquid.

For small baths a neat form of vessel consisting in a square porcelain-lined (enameled) iron tank of suitable dimensions is sold by some of the dealers in electroplating materials.

ANODES OR FEEDING PLATES.

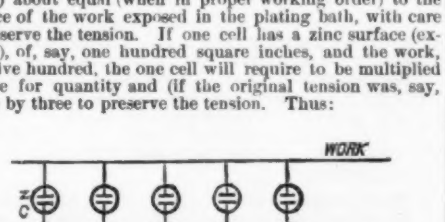
Good pure cast nickel anodes are now obtained at a moderate cost ($1.85 per lb.), and are preferable to grain metal anodes. They usually come in sizes ranging from 1¾ x 4 inches, 3/16 inch thick, to 8 x 12 inches, 5/8 inch thick.

They may be suspended around the sides of the tank or across and facing the work (care being taken to avoid bringing them into such close proximity to the work that contact is likely to occur under any circumstance). They may be suspended by clean copper trusses or hooks—which should not be permitted to touch the liquid—from stout copper rods, to which connection with the battery is made.

THE BATTERY.

In nearly all large electroplating establishments some form of dynamo-electric machine is now used instead of the battery. They are cleanly, require little attention and space, and afford a current more easily adapted to the work, and at a much smaller cost.

But as their first cost is considerable, and they require power to operate them, the old battery is still in requisition in smaller establishments. The carbon or chromic acid battery* is more commonly used, as it admits of more rapid work with a smaller number of cells; but as it supplies a very intense current, it often becomes necessary to introduce resistance coils to reduce it where small work is on hand. Some of the best work we have ever seen has been produced with the current derived from two or three Smee or sulphate of copper cells (in series). The amount of battery power for a given amount of work should be in zinc surface (exposed) about equal (when in proper working order) to the surface of the work exposed in the plating bath, with care to preserve the tension. If one cell has a zinc surface (exposed), of, say, one hundred square inches, and the work, say, five hundred, the one cell will require to be multiplied by five for quantity and (if the original tension was, say, three) by three to preserve the tension. Thus:



Of course this is equivalent to three large single cells, each exposing five hundred square inches of zinc (equal to a plate about sixteen inches square, exposing both sides). Large batteries of the dipping form, admitting of the immersion of the proper quantity of zinc, are often convenient.

If the current is too strong the deposited metal will present a dull (commonly termed burnt) appearance; if too weak it is apt to be imperfect, granular, or semi-crystalline.

For practical purposes the electricity may be said to proceed from the copper or carbon pole of the battery, and care should be taken that this pole is invariably connected (by stout copper wires or rods) with the anodes or feeding plates in the plating bath, for if misconnected damage is done both to the work and the bath by the corrosion or partial solution of the former in the latter.

* See SCIENTIFIC AMERICAN SUPPLEMENT, Nos. 157, 158, and 159, for descriptions of batteries.

PREPARING THE WORK.

Before work can be plated its surface must be freed perfectly from all traces of oil or grease, oxides, lacquer, and other impurities. Oil, grease, etc., are removed by contact with a strong, hot aqueous solution of caustic potash, and, after rinsing off the adhering alkali, from oxide by an acid bath; or, if of brass, copper, or German silver, by scouring with fine pumice stone and strong aqueous solution of cyanide of potassium. Iron is pickled in dilute sulphuric or muriatic acid (acid 1, water 5 to 15), and scoured with fine white silicious sand or pumice stone. Brass or copper is sometimes brightened before entering to the plating bath by dipping it momentarily in nitric acid diluted with about twenty parts of water, and quickly rinsing it in running water. It should be placed in circuit immediately after this.

The hand must not come into contact with any part of the work after removal from the alkali, as the slightest touch may spoil all.

On removal of the plated work from the plating bath it should be quickly rinsed (without handling) in cold water, then transferred to hot water, which will cause it when taken out to dry quickly and perfectly. If the finished work is to present a smooth polishing surface it must present such a surface before entering the plating bath. Nickel is hard and will not readily submit to a burnishing tool.

When the work is placed in circuit in the plating bath (and it should not be permitted to remain many moments in the bath without being placed in circuit) it should be moved about to free it from bubbles.

The process of nickel plating is a simple one, and by a little practice and proper attention to the requirements the bath may be worked month after month, and the metal deposited smoothly and with certainty.

COPPER DEPOSITS.

Where it is intended to simply coat or plate another metal or alloy, the electro-deposit of copper is usually obtained by the decomposition of a double salt, such as the cyanide of copper and potassium. This process is adapted to most metals, and affords a fine uniform deposit. The following is a good bath of this description:

Water (soft)	1	gall.
Acetate of copper (cryst)	3½	oz.
Carbonate of soda (cryst)	3½	"
Bisulphite of soda	3	"
Cyanide of potassium (pure)	7½	"

Moisten the copper salt with water to form a paste (otherwise it is apt to float on the liquid); stir in next the carbonate of soda with a little more water, then the bisulphite, and finally the cyanide with the rest of the water. When solution is complete the liquid should be colorless. If not, add cyanide until it is.

The bath may be employed hot or cold, and requires a moderately strong circuit of electricity. A copper plate forms the anode, and it should expose surface enough to supply the loss of copper—at least a surface equal to that of the work. It must be removed when the bath is not in use.

If the liquid becomes colored, more cyanide must be added.

Large pieces are generally kept hanging motionless in the bath while the plating is in progress; small articles are moved about as much as possible, especially if the bath is warm.

The formula for the bath given above requires pure cyanide of potassium, and where the commercial article, which is often very impure, is used instead, considerable allowance must be made. The following formulæ require a cyanide containing 70 to 75 per cent. (a good average) of pure potassium cyanide:

COLD BATH FOR IRON AND STEEL.

Acetate of copper	3	oz.
Carbonate of soda	6¼	"
Bisulphite of soda	3¼	"
Cyanide of potassium	3¼	"
Water	1	gall.
Aqua ammonia	2¼	fl. oz.

Prepare as before.

WARM BATH.

Acetate of copper	3¼	oz.
Carbonate of soda	3¼	"
Bisulphite of soda	1¼	"
Cyanide of potassium	4¼	"
Water	1	gall.
Aqua ammonia	1¾	fl. oz.

HOT OR COLD BATH FOR TIN, CAST IRON, OR LARGE ZINC PIECES.

Acetate of copper	12¼	oz.
Bisulphite of soda	10	"
Cyanide of potassium	18	"
Water	5¼	gall.
Ammonia (aqua)	7	fl. oz.

For small articles of zinc, which are coppered in a perforated ladle and in nearly boiling baths:

Acetate of copper	16	oz.
Bisulphite of soda	3½	"
Cyanide of potassium	25	"
Aqua ammonia	5½	"
Water	4 to 5¼	galls.,

In the preparation of these baths the salts are all dissolved together, except the copper acetate and ammonia which are added after dissolving together in a small quantity of the water.

The deep blue color of the ammonio-copper solution should entirely disappear on mixing it with the other solution; otherwise, it becomes necessary to add more cyanide.

The cold bath is put into well joined tanks of oak or fir wood, coated inside with gutta percha or asphaltum (genuine). The vertical sides are also covered with sheets of copper, all connected with the last carbon or copper of the battery by a stout copper wire with well-cleaned ends, the other pole of the battery being in similar connection with a stout brass rod extending the length of the tank (without any point of contact with the anodes), and from which the work is suspended by hooks or trusses in the bath.

With a thin deposit the coating is sufficiently bright to be considered finished after being rinsed and dried. But if the operation is more protracted the deposit has a dead luster on account of its thickness, and if a bright luster is desired it is necessary to use the scratch brush.

The hot baths are usually put into stoneware vessels heated by a water or steam bath, or into an enameled cast iron kettle placed directly over a fire. The vessels are lined inside with copper, the edges of the vessels being varnished, or support a wooden ring upon which rests a brass circle connected with the zinc pole of the battery. The objects to be electroplated are suspended from this ring.

The hot process is more rapid than the cold, and is especially adapted to those articles which are difficult to cleanse. The articles are kept in continual agitation, which permits of the employment of a strong current of electricity. Small articles of zinc are placed in a perforated stoneware or enameled ladle, at the bottom of which is attached a copper wire which is wound up around the handle and connected with the zinc pole of the battery. It is sufficient that one of the small articles touches the wire for all to be affected by the current, as they are in contact with each other. The ladle must be continually agitated, so as to change the points of contact of the objects. What has been said in regard to strength of battery, in the article on electro-brass plating, will apply here.

COPPER DEPOSITS BY DIPPING.

This is seldom practiced except upon iron, as deposits thus obtained are generally wanting in lasting qualities, since, from the thinness of the coating, the iron is but imperfectly protected from atmospheric influences. If the iron is dipped in a solution of—

Sulphate of copper	3½ oz.
Sulphuric acid	3½ "
Water	1 to 2 galls.,

it becomes covered with a coating of pure copper, having a certain adhesion; but should it remain there a few minutes, the deposit becomes thick and muddy, and does not stand any rubbing. Small articles, such as pins, hooks, and nails, are thus coppered by tumbling them for a few moments in sand, bran, or sawdust impregnated with the above solution diluted with three or four volumes of water.

ELECTRO-BRASS PLATING.

Many articles of bronze composition, of zinc, or cheap alloys receive a coating of brass by electric deposition, as a basis for the bronze luster, which is more easily applied and better retained by such a surface. The brass finish is also applied by this method to iron, steel, and composition wire.

The preliminary and finishing operations and the disposition of the baths are the same for brass as for copper deposits. Heat is applied for brass deposits by those who electroplate coils of iron of composition wire, etc., with this alloy. For other articles the baths used are not usually heated. The hot bath is usually contained in an oblong open iron boiler lined with sheet brass, while that for cold plating is generally placed in a wooden tank coated with gutta percha or asphaltum. The anodes are of plate or sheet brass joined together and arranged along the sides, all connected with the last carbon or copper of the same battery. The strength of battery current is regulated by the surface of the articles to be electroplated. The articles are suspended in the usual way—by copper or brass hooks to stout rods of the same metal, all connected with the last zinc of the battery.

THE BRASS BATHS.

Where the ordinary cheap commercial cyanide is employed the following answers very well:

Sulphate of copper	4 oz.
Sulphate of zinc	4 to 5 oz.
Water	1 gall.

Dissolve and precipitate with 30 ounces carbonate of soda; allow to settle, decant the clear liquid, and wash the precipitate several times with fresh water—after as many settlings. Add to the washed precipitates:

Carbonate of soda	15 oz.
Bisulphite of soda	7½ oz.
Water	1 gall.

Stir to effect solution of these last two, then stir in ordinary cyanide of potassium until the liquid becomes clear and colorless. Filter if much iron or iron oxide (derived from impure zinc salt and cyanide) remains suspended in the liquid. An additional half ounce or so of the cyanide improves the conductivity of the solution.

COLD BRASS BATH FOR ALL METALS.

Carbonate of copper (recently prepared)	2 oz.
Carbonate of zinc " "	2 "
Carbonate of soda	4 "
Bisulphite of soda	4 "
Cyanide of potassium (pure)	4 "
Arsenious acid	$\frac{1}{25}$ "
Water	1 gall.

Filter if necessary.

The arsenious acid is added to brighten the deposit—an excess is apt to give the metal a grayish-white color.

MANAGEMENT OF THE BATH.

The losses of the bath are to be repaired by the addition of copper and zinc salts (and arsenious acid) dissolved in fresh cyanide, and water.

The operator determines the requirements from the rapidity of the deposit, its condition, color, and so on.

The difficulty in brass electroplating, especially with small baths, is in keeping the uniformity of the color of the deposit, as the electric current having to decompose two salts, each offering a different resistance, must, according to its intensity, vary the color and composition of the deposit. A feeble current principally decomposes the copper salt and results in a red deposit; while too great intensity in the current decomposes the zinc salt too rapidly and the deposit is a white or bluish-white alloy. If the deposit has an earthy or ocherous appearance, or if the liquid is blue or greenish, the solution is deficient in cyanide. When in proper working order the liquor is colorless. If the coating becomes dull and unequal, a slight addition of arsenious acid will usually improve it.

If the deposit is too red, use more battery power or add more zinc salt; if too white, decrease the current or add more copper salt. The specific gravity of the bath may vary from 5° to 12° Baumé; when it exceeds this latter gravity it should be diluted with fresh water to decrease the electric resistance.

If the brass deposit is irregular, remove the articles from the bath, rinse, scratch-brush, and put again into the bath until the color and thickness of the deposit are satisfactory. Scratch-brush again, and, if necessary, rinse in hot water, dry in warm white wood sawdust, and put in the stove room. The last three operations are indispensable for hollow pieces.

In the disposition of the brass plating bath it is always necessary to have all the articles suspended at about equal distances from the anodes.

The bath may be subdivided by several anodes, forming partitions, so that each loaded rod is between two anodes.

The anodes should always be removed when the bath is not in use.

In order that the brass electroplating of zinc or copper may be lasting the deposit must not be too thin, and must be scratch-brushed, washed in lime water, and dried in the stove room.

Generally ten to twenty-five minutes' exposure in the bath suffices in ordinary practice to throw on a good coating. Cast and wrought iron, lead and its alloys require a bath richer in the metals than when brass plating zinc or its alloys. The battery power should also be greater. For lead the bath works better warm (at about 90° Fah.). When once placed in the brass bath articles should not be moved about, as there is a tendency under such circumstance to the formation of a red deposit.

In brass plating wire the hot bath is usually employed. As before mentioned, the vessel containing the bath usually consists in an oblong open iron boiler, lined with sheet brass anodes, and heated by fire, steam, or hot water. A stout copper or brass rod in the direction of the length of the boiler rests upon the edges, from contact with which it is insulated by pieces of rubber tubing. The rod is connected with the zinc pole of the battery. The binding wires are removed from the coil, the wires loosened, and the ends bent together into a loop. The wire is then dipped into a pickle of dilute sulphuric acid, and hung upon a stout round wooden peg fastened in the wall, so that the coil may be made to rotate easily. After a scrubbing with wet sharp sand and a hard brush the coil is given a primary coating of copper. It is then suspended to the horizontal rod, where only a part of the coil at a time dips into the solution and receives the deposit; the coil is then turned now and then one-half or one-fourth of its circumference. By dipping the coil entirely into the liquid the operation is not so successful.

The wires are washed, dried in sawdust, and then in the stove room, and lastly, passed through a draw plate to give them the fine polish of true brass wires.

The temperature at which the hot bath is commonly used varies between 130° and 140° Fah.

TIN-PLATING PROCESS.

Perhaps the best and cheapest substitute for silver as a white coating for table ware, culinary vessels, and the innumerable articles of manufacture requiring such a coating is pure tin. It does not compare favorably with silver in point of hardness or wearing qualities, but it costs very much less than silver, is readily applied, and easily kept clean and bright.

There are several methods in use by which small articles—wire, etc.—of iron, copper, brass, zinc, and composition are tin plated. These are:

1. By contact with melted tin.
2. By tin amalgam.
3. By simple immersion.
4. By battery.

The contact process is that by which all sheet tin, or, more properly, tinned sheet iron, is produced. A description of this process as applied to tin plate will be found on page 68, current volume, SCI. AM.

In tinning hollow ware on the inside the metal is first thoroughly cleansed by pickling it in dilute sulphuric (or muriatic) acid, and scouring it with fine sand. It is then heated over a fire to about the melting point of tin, sprinkled with powdered rosin, and partly filled with melted pure grain tin covered with rosin to prevent its oxidation. The vessel is then quickly turned and rolled about in every direction so as to bring every part of the surface in contact with the molten metal.

The greater part of the tin is then thrown out, and the surface rubbed over with a brush of tow to equalize the coating. The operation is repeated, if necessary. The vessels usually tinned in this manner are of copper and brass, but with a little care in cleansing and manipulating iron can also be satisfactorily tinned in this manner.

The vessels must be hot enough to keep the tin contained in them fused.

The amalgam process is not used so much as it was formerly. It consists in applying to the clean and dry metallic surface a film of a pasty amalgam of tin with mercury, and then exposing the surface to heat, which volatilizes the latter, leaving the tin adhering to the metal.

The immersion process is best adapted to coating articles of brass or copper. When immersed in a hot solution of tin properly prepared the metal is precipitated upon their surfaces. One of the best solutions for this purpose is the following:

Ammonia alum	17½ ounces.
Boiling water	12½ pounds.
Protochloride of tin	1 ounce.

The articles to be tinned, first thoroughly cleansed, are put into the hot solution until properly whitened.

A better coating can be obtained by using the following bath, and placing the pieces in contact with a strip of clean zinc, also immersed:

Bitartrate of potassa	14 ounces.
Water (soft)	24 "
Protochloride of tin	1 ounce.

It should be boiled for a few minutes before using.

The following is one of the best solutions for plating with tin by the battery process:

Potassium pyrophosphate	13 ounces.
Protochloride of tin	4½ "
Water	20 "

The anode or feeding plate used in this bath consists of pure Banca tin. This plate is joined to the positive (copper or carbon) pole of the battery, while the work is suspended from a wire connected with the negative (zinc) pole. A moderately strong battery is required, and the work is finished by scratch-brushing.

In Weigler's process a bath is prepared by passing washed chlorine gas into a concentrated aqueous solution of stannous chloride to saturation, and expelling excess of gas by warming the solution, which is then diluted with about ten volumes of water and filtered, if necessary. The articles to be plated are pickled in dilute sulphuric acid, and polished with fine sand and scratch-brush, rinsed in water, loosely armed with zinc wire or *tape*, and immersed in the bath for ten or fifteen minutes at ordinary temperatures. The coating is finished with the scratch-brush and whiting.

By this process iron—cast or wrought—steel, copper, brass, and lead can be tinned without a separate battery. The only disadvantage of the process is that the bath soon becomes clogged up with zinc chloride, and the tin salt must be frequently renewed.

In Hern's process a bath composed of—

Tartaric acid	2 ounces,
Water	100 "
Soda	3 "
Protochloride of tin	3 "

is employed instead of the above. It requires a somewhat longer exposure to properly tin articles in this than in Weigler's bath. Either of these baths may be used with a separate battery.

ELECTROTYPY.

In taking impressions or moulds of *under-cut* or highly-wrought work it is necessary to use a flexible substance to admit of separating the mould and model without injury to either. For these purposes gelatine—or gelatine and glue or sirup—and gutta percha are employed. Glue (of the finest quality) or gelatine is softened by soaking over night in cold water, then removed from the water and dissolved by aid of heat in a quantity of pure glycerine equal to the dry glue taken. This mixture is kept over the water bath for several hours, and is then ready to pour over the warm, well-oiled model. After standing for several hours, or until thoroughly cooled, it may be removed from the model by careful manipulation. When removed it is dipped repeatedly in a solution of one ounce chromic acid in a quart of water, each time being exposed to strong sunlight (every part), which renders the surface waterproof and non-absorbent. When dry the surface may be metallized, and a strong current with a large anode used at first in the bath. With such work much care is necessary to exclude air bubbles from the deep-wrought portions.

In using gutta percha the moulding operation is conducted either by press, by hand, or in a stove.

By Hand.—After purification in boiling water, plates of various thicknesses or lumps are formed.

A quantity sufficient for the intended mould is cut and put into cold water, which is gradually heated until the gutta percha is soft enough to be kneaded like dough. After having pulled the gutta percha in every direction the edges are turned in so as to form a kind of half ball, the smooth convex side is applied to the middle of the model, then it is spread over and forced to penetrate the details of the object. The kneading is continued as long as the material remains sufficiently soft, when it is allowed to cool somewhat. While at a temperature of about 80° Fah. it is separated from the model and dipped into cold water to harden, and may then be handled without danger of impairing its accuracy.

With some models it is preferable to heat the gutta percha in a copper dish with constant stirring until it becomes a semi-fluid paste. This is poured over the pattern previously placed in an iron ring. After a few minutes it may be kneaded in with wet or oiled fingers until it scarcely yields to pressure. In removing the mould from the pattern all useless parts, especially those which have passed under the pattern and bind it, must be first removed. Then the proper position and shape of the covered pattern must be ascertained so as not to break the model or tear the gutta percha.

For moulding by sinking or kneading the following composition is preferable to pure gutta percha: Gutta percha, 2 parts; linseed oil, 1 part. Heat the oil in a copper vessel to about 212° Fah., then gradually stir in the gutta percha cut fine. When the whole is in a pasty form and begins to swell up with the production of thick fumes, throw the contents of the kettle into a large volume of cold water, where, without loss of time, the paste must be kneaded, and, while still hot, rolled upon a slab of marble and passed between mediumly warm rollers.

Gutta percha may be used an indefinite length of time.

In Moulding by Press.—After the object has been coated with plumbago or tallow it is put square and firm upon the table of a screw press, and surrounded with a frame or ring of iron a little higher than the most raised portions of the model. A piece of gutta percha at least the thickness of the pattern is cut so as to fit the ring or frame of iron, and then heated on one of its faces only before a bright fire. When about two-thirds of its thickness has been softened it is placed, soft portion downward, in the iron ring or frame and the whole covered with a block of metal exactly fitting. It is put under light pressure at first, the force being increased as the gutta percha becomes harder or more resisting.

Stove moulding is resorted to with models the brittleness of which renders them liable to injury when pressure is applied—plaster of Paris, alabaster, marble, etc. The object is placed upon a plate of iron or earthenware, a ball of gutta percha is placed on the middle of the object, and the whole is set in an oven where the temperature is just sufficient to melt the gutta percha, which, as it softens, penetrates all the details; when it has sunk completely it is removed from the oven and allowed to cool off until it retains just enough elasticity to be separated from the pattern.

Gutta percha is entirely insoluble in water, weak acids, or acid salts. When moulded it is prepared for the deposition of metal by being coated with a film of graphite or bronze powder.

REPRODUCTION OF MEDALS, ETC.

There are several methods by which medals may be reproduced, and of these the following are the simplest and afford the most satisfactory results:

THE STEREOTYPE PROCESS.

The medal, thoroughly cleansed dried, and coated with a thin but uniform film of pure sperm or olive oil, is bound around the edge with a piece of cardboard so as to form a box, the bottom of which is the medal. A small quantity of finest plaster of Paris is then mixed up quickly into a thin cream and applied all over the exposed surface of the medal with a camel's-hair pencil so as to fill all depressions and exclude air bubbles. A thick cream of plaster is then at once poured in until the box is nearly or quite filled. When the plaster has properly hardened the cardboard is taken off, and the plaster adhering to the rim of the medal trimmed off with a knife; the medal can then be easily detached from the cast. Another cast may then be taken of the reverse side of the medal in a similar manner. These casts, after trimming, are set aside in a warm place until they become quite dry, and are then clamped securely, face upward, in a small shallow iron tray, so that their face is about half the thickness of the medal distant below the top or edge of the tray. The spaces in the tray about the casts are then filled up even with the inferior edge of the casts with plaster, *papier mâché*, or

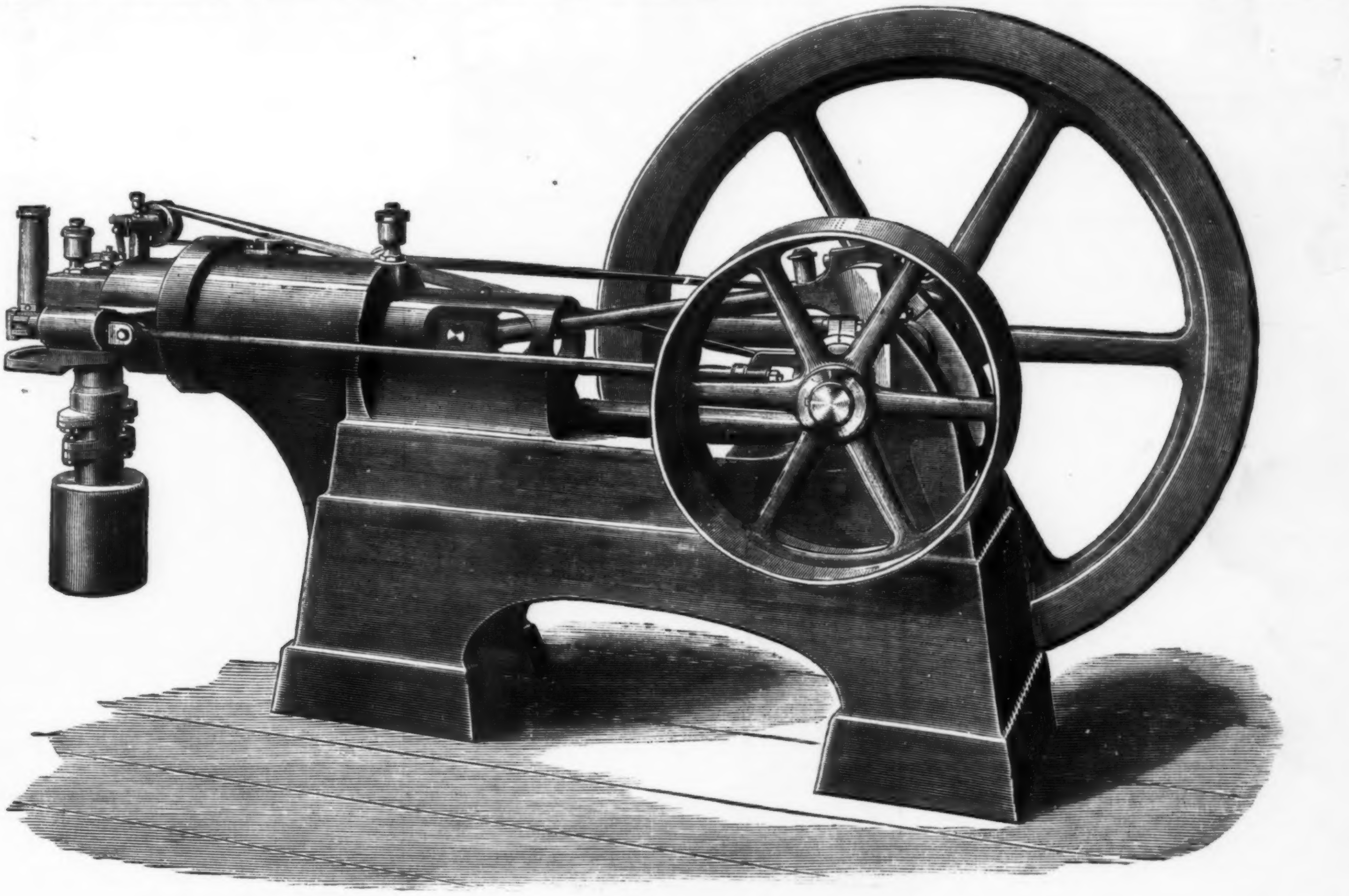
clay (dry). The tray thus arranged is put into an oven until the temperature of its contents is uniformly heated to about 250° Fah., when it is removed and immersed wholly below the surface of a potful of ordinary type metal heated just hot enough to make it quite liquid. As soon as air bubbles cease to escape the tray is slowly and steadily raised out of the pot, and the contents allowed to chill and harden in the air (sometimes it is preferable to plunge it in water, so as to facilitate the removal of the "cake" from the tray). When the plate of type metal is cut out of the tray a correct (reversed) copy of the plaster moulds will be found on its under surface, and when the superfluous metal has been cut away and the pieces trimmed to proper dimensions and thickness they may be soldered together back to back, and the edges cut, turned, or milled, as the case requires to produce a correct imitation of the original medal. Cleansed by dipping momentarily in a strong hot solution of caustic potash, and, after quickly rinsing in running water, in hydrochloric acid, it may be coated with silver or copper, if desired, by electro deposition.

BY ELECTROTYPY.

Melt pure white wax, and stir well into it while cooling about one-fifth its weight of finest flake white (plumbic carbonate). Having uniformly coated the faces of the medal with a film of finest graphite or plumbago, arrange it in the box of cardboard as in taking the plaster stereo cast, and pour in the wax preparation previously heated just enough to make it semi-fluid. Having thus obtained a mould in wax of both faces of the medal, harden the wax in a cool place, then coat it perfectly with a film of pure graphite, wrap about the edges a number of turns of clean copper wire, and brush on plumbago so that the film of the latter may have contact with the wax and wire all around. Suspend the wax cast thus prepared by the copper wire in a saturated (or nearly saturated) aqueous solution of *pure* sulphate of copper, jarring it so that all bubbles of air may escape from the deep lines of the cast. Close in front, but not touching the immersed mould (or its connections), suspend by a copper wire a sheet of clean copper. Connect the copper by stout copper wire with the silver (or carbon) pole of a Smee battery of three cells (in series), and the copper wire on the mould, in a similar manner, with the zinc pole of the same battery, and let the deposition of copper on the mould proceed until it becomes thick enough to separate without breaking (about as thick as this paper). Then carefully detach it from the mould, embed the pieces, face downward, in dry plaster, and fill up (after drying) with melted type metal (or fusible metal). Trim to proper size and thickness, solder the pieces together, back to back, and cut or mill the edges to proper form. These *copies* may be coated with a thin film of silver by electro deposit. The surfaces may be given an *aged* appearance by immersing them for a few moments in a dilute solution of sulphide of soda in warm water.

When a copy, as produced by stereotypy, of a medal is taken in metal, the latter coated with plumbago, and immersed in a bath composed of three quarters of a pound of sulphate of nickel and ammonia per gallon of water, under the conditions described in electrotyping with copper, a hard shell of nickel is obtained, which, when separated and backed with type metal, may be used as a die. It is difficult, however, for an amateur in electro metallurgy to obtain good results in this way. Steel dies cannot be produced in this way. Moulds for stereo or ordinary casting should be heated.

For a fusible silver-white alloy melt type metal and mix it with one-eighth its weight of grain tin, remove from the fire, and stir well before pouring.



CLERK'S GAS ENGINE AT THE PARIS ELECTRICAL EXHIBITION.

GAS ENGINES AT THE PARIS ELECTRICAL EXHIBITION.

A NEW gas engine is exhibited by Messrs. Thomson, Sterne & Co., of London and Glasgow. We give a perspective view. All, or nearly all, the gas engines which have been successfully brought out have compressed the charge of gas and air, but have made only one ignition to every two revolutions. Clerk's new engine makes one ignition for each revolution. This, it need hardly be said, nearly doubles the power of the engine, though it adds a little to its weight.

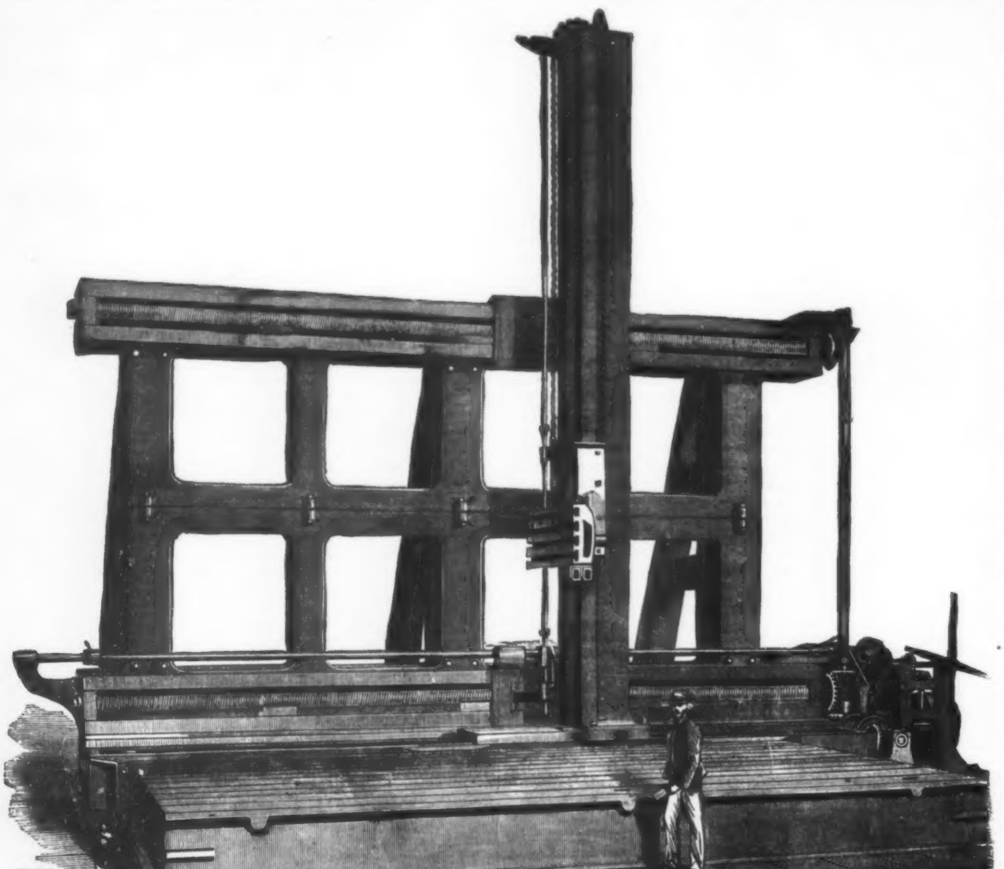
The engine exhibited at Paris has a motor cylinder of 6 in. diameter, and a light displacer cylinder, as it is termed, of larger diameter. The stroke of the piston is 12 in., and it is connected to a crank by the usual rod; but the pressure in the displacer cylinder never exceeding about 5 lb. per square inch, the connections are very light, and it is driven from a pin on one of the flywheel arms. The displacer crank pin is in advance of the motor crank, and at a right angle thereto. When it moves forward the combustible mixture of gas and air is drawn into the displacer cylinder during the first half of the piston's stroke, at which point the gas is cut off, and only air admitted for the remaining part of the stroke. The displacer on its return stroke discharges its contents through a lift valve into the motor cylinder, the piston of which is hot at the outer end of its stroke, and has uncovered an annular port in the cylinder communicating with the exhaust pipe. When this part is uncovered the hot products of combustion discharge through it until the pressure in the cylinder has fallen to atmospheric pressure, when the air from the displacer entering at the back end, expels the remaining hot exhaust and passes in part through the exhaust pipe. The cylinder is now filled with fresh air, and when the combustible mixture enters, displacing in turn the air, the cylinder contains nothing but an ignitible mixture and air.

The motor cylinder in its instroke compresses the mixture into a space at the end of the cylinder, the pressure rising to 45 lb. above atmosphere. Ignition then takes place, and the pressure rises to from 200 lb. to 250 lb. per square inch above atmosphere. The piston moving forward, the pressure gradually falls, and when the end of the stroke is reached the exhaust discharges at about 30 lb. above atmospheric pressure. This cycle of operations is repeated at every stroke. In larger engines, the terminal pressure before exhausting is, we are informed, very much less than 30 lb., sometimes as low as 5 lb., above atmosphere; but this is obtained by an arrangement which allows of a greater expansion. The volume swept through by the displacer piston is greater than the combined volume of the motor cylinder and space at the end of it into which the ignitible mixture is compressed; as half of its charge is fresh air, it follows that at every stroke of the engine the whole of the products of combustion are discharged and replaced by fresh cool air, before any combustible mixture is allowed to enter. This arrangement produces great certainty in the action of the engine. A great obstruction to progress in constructing large or powerful gas engines has hitherto been premature ignition. The combustible mixture, entering the cylinder still containing products of the previous combustion, ignites at the wrong time either by flame still burning in the cylinder, or by sparks on the walls of the combustion chamber due to the ignited carbon from the decomposition of the oil used in lubricating. To secure freedom from these irregular ignitions, it is necessary first to clear out thoroughly any hot burned gases; and second, secure a sufficiently low mean temperature of cylinder surface and combustion chamber, so as to render the existence of sparks impossible. The object is attained by the use of the displacer cylinder, as the charge is not compressed in the cylinder, but merely passed into the motor cylinder at such a pressure above atmosphere as is necessary to lift the valve, and so discharge the exhaust. It follows that it may be made of any size found necessary to pass the volume of air for clearing and cooling.

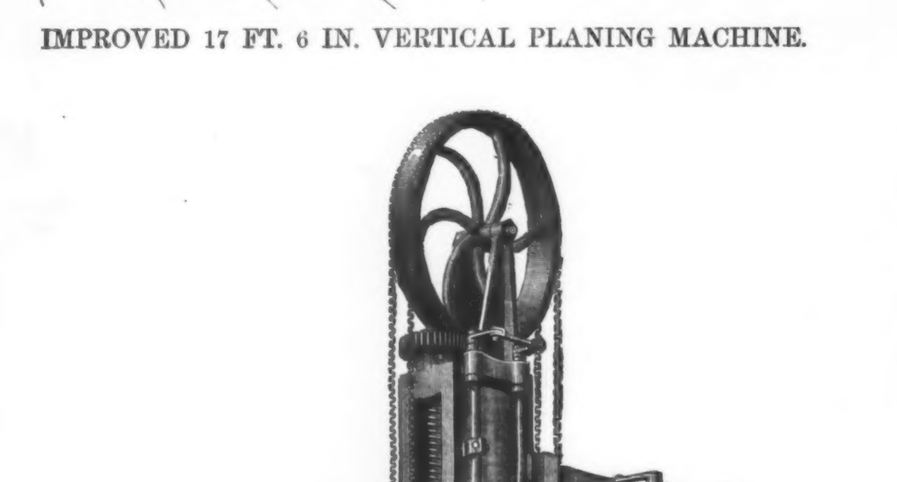
This device is the essential feature of the engine. In previous gas engines it was sought to be attained by igniting but once in two revolutions, or even once every third revolution, to prevent premature ignition; but although this succeeds success is purchased at the cost of a great loss of possible power. It is found by the prolonged experience of those using engines igniting every second revolution, that when working at full power they back ignite very often, and it is only when running light that they are free from this. The larger the engine the greater tendency to back ignition, and the less possibility of using the engine at its full number of ignitions. This seems to be so far prevented in Clerk's gas engine that it may be continuously worked up to its full power, igniting at every revolution without irregularity or stoppage.

The arrangements for admitting gas and air, for cutting off the gas at the proper time, for igniting, and for exhausting, are of a simple character. An automatic lift valve serves to admit the mixed charge of gas and air to the displacer cylinder; another similar valve passes the charge from the displacer to the motor cylinder. A small slide in the back of the engine, worked by an eccentric on the main shaft, both ignites the charge at the proper time, and cuts off the supply of gas to the displacer at half its stroke. There is no exhaust valve. The piston uncovers the annular port at the outer end of its stroke, and the exhaust is discharged, and a fresh combustible mixture is passed into the cylinder by the displacer before it returns. The igniting arrangement differs from that ordinarily used in gas engines. This is necessitated by the much greater number of ignitions to be accomplished per minute. The arrangement used by Mr. Clerk is capable of making 300 ignitions per minute. The ignition slide has in it a small cavity, from each end of which is a port opening at opposite faces; at one end of this cavity there is a perforated plate, through which ignitible mixture passes from the motor cylinder, the communication being made by a small hole in the slide, and a gutter in the slide face, which is constantly on the hole in the port face leading to the combustion chamber. The mixture, after passing through the perforated plate or grating, is lighted by a Bunsen flame, and, burning at the grating, fills the cavity completely with flame and discharges at the port in the face.

The movement of the slide causes this part to open on a small port in the port face, direct into the combustion chamber, causing the immediate ignition of the charge. The movement of the slide, of course, cuts off all communication with the atmosphere before communicating with the cylinder. The ignition port is extremely small, only ¼ in. by ¼ in., so that the pressure necessary to keep the slide to its face is but slight, even at the high pressure of 250 lb. per square inch. By this arrangement the whole slide is of small dimensions, and there is no necessity for ventilating the port, as the mixture from the cylinder requires no exterior aid to support its combustion. The frequency of ignition, therefore, is thoroughly within control. The two automatic lift valves which, if used in the ordinary way, would cause considerable rattle, are rendered perfectly silent by a very simple arrangement of air cushions. The engine exhibited gives 6 horse-power on the brake at 145 revolutions, and indicates about 10-horse power. This is a higher power than that given off by other engines with



IMPROVED 17 FT. 6 IN. VERTICAL PLANING MACHINE.



IMPROVED 4 FT. STROKE VERTICAL SLOTTING MACHINE.

similar cylinder capacity. Mr. Clerk's engine is well-designed, and promises to be highly successful.—*The Engineer.*

LARGE PLANING AND SLOTTING MACHINES.

WE give illustrations of two machines, prepared from photographs furnished by the makers, Messrs. Smith, Beacock & Tannett, of Leeds. The largest of these machines is the vertical and horizontal planing machine. This machine planes vertically 17 ft. 6 in., and horizontally 21 ft.; the one motion can be changed for the other in half a minute. The work is secured to a base plate, which is so fastened to the framing of the machine that the strain of a large cut at any part of this large surface is effectually resisted. The various slides and their supports have been accurately fitted and secured at right angles to each other, so that the bed-plate columns and cylinders of a very large engine have been put together from this machine with accuracy.

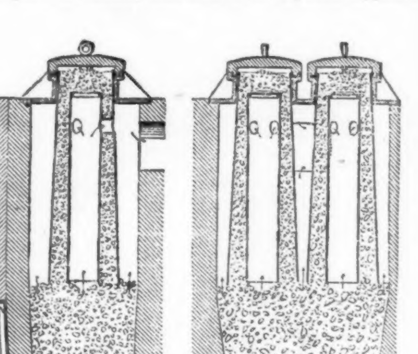
It will be seen that while one job of moderate size is being planed, another may be fixed ready for the tool to come to it, and the loss of time in setting and resetting, which ordinary planing machines incur, is in this machine avoided. The finishing cut, which may be as much as 1½ in. at a stroke, is put on by hand.

This machine is driven by a special double-cylinder wall engine.

Another machine for dealing with large forgings is the slotting machine with a 4 ft. stroke. The vertical slide of this machine is adjustable, so as to deal with the various thicknesses of the work to great advantage. The slides which carry the table of the machine are worked by double screws to prevent the springing of the work away from the cut. One great advantage of this machine is that the workman can change the stroke from 4 in. to 4 ft. in a few seconds.—*The Engineer.*

KRUPP'S IMPROVED GAS GENERATORS COMPARED WITH THE OLDER APPARATUS OF SIEMENS.

IN the old Siemens gas generators at the Krupp Steel Works, there is consumed per 12 hours about 1,200 kilogrammes of gas coal, from the Hanover Mine, containing 6 to 6·7 per cent. of ash; but in the new improved apparatus



KRUPP'S GAS GENERATOR.

the quantity consumed is 1,500 kilogrammes, and, by forcing the operation, 2,000 kilogrammes of ordinary steam coal, yielding on an average 11·5 per cent. of ash. Both systems were rendered active by the Körting injector. It is well known that the ashes under the grates of the old gas generators contain a large quantity of unconsumed coke. The ashes of the new apparatus are, on the contrary, almost entirely burnt out, and consequently nearly every bit of the fuel is converted into gas and utilized.

Coal gas costs about 10 francs per ton, and that for steam boilers, 5.25 francs.

MEAN COMPOSITION OF THE COMBUSTIBLE GASES.

	Gas Generators.	
	Old.	New.
Carbonic oxide	18 per cent.	25 per cent.
Hydrogen....	10 " "	12 " "
Carbureted hydrogen	2 " "	2 " "
	30 " "	39 " "
There is, in addition of Carbonic acid...	6·8 " "	2·4" "

The work of the stoker is considerably lessened, since, in addition to the regular cleaning of the grates, no difficult labor presents itself. Three workmen are sufficient to attend to eight generators.

The economy resulting solely from the use of a lower priced coal has been found to be (10—5.25 francs)=4·75 francs per ton.

Allowing, then, that in the old apparatus there are consumed only 1,200 kilogrammes per 12 hours, there is effected by the new apparatus an economy of 2×1·27×300 days×4·75 francs=3,420 francs per year and per generator.

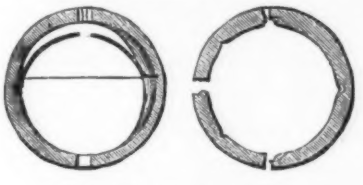
In addition to these important advantages, other indirect ones have also been found; as, for instance, an economy in the work of the corps of stokers resulting from a better utilization of the general arrangement, since no loss of gas occurs in the charging of the new generators. And, finally, there is a diminution in the cost of maintenance.

ON THE MANUFACTURE OF PROJECTILES.

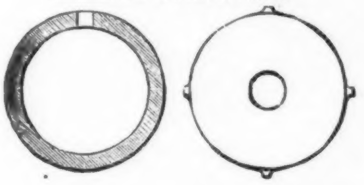
By MR. J. DAVIDSON.

In this paper, lately read before the Iron and Steel Institute, the main features of the manufacture of projectiles in the Royal Laboratory at Woolwich were described. The War Department in 1857 appointed a committee of officers belonging to the Arsenal to consider the advisability of establishing a foundry for the manufacture of projectiles to meet the requirements of both army and navy. The deliberations of that committee resulted in the establishment of an experimental foundry, in which two small cupolas were erected; and it was not long before the introduction of moulding machines was suggested, with the view of securing a large output in numbers, and at the same time reducing the amount of skilled labor and the cost of production to a minimum. Machinery of this description was not then in existence, and an inquiry led to the firms of Messrs. Fairbairn, Greenwood, and Batley, of Leeds, and Messrs. Higgins & Co., of Manchester, submitting designs of machines

SPHERICAL SHRAPNEL SHELL



SPHERICAL COMMON SHELL



for the purpose. The principle of removing the pattern or lowering it through a fixed plate was in both cases adopted, but the method submitted by Messrs. Fairbairn, Greenwood and Batley proving the most effective, was, and has since been, almost wholly in use, the modification of a "screw" in place of "rack and pinion" having to be used for the large natures of projectiles. The core-box machines consist of two halves, forming the desired shape of core, and these were made to recede and face each other by means of a right and left-handed screw. So marked was the success obtained in this small foundry, that it was decided to erect the foundry to which this paper especially applies, and which was designed to give an out turn of 600 tons per week; the 6in. spherical projectiles being the means taken to estimate the extent of space required. The foundry having been supplied with its complement of machinery and put into actual working order in the financial year 1858-59, its capabilities were shown by an average output of 500 tons per week for the whole of that year. The supply by the Elswick firm of projectiles as well as guns may be said to have virtually—for the time—stopped the manufacture of all spherical work; but it was seen that in most cases a slight modification or alteration of our existing machines would place them in a condition to proceed with the class of projectiles called for, and it was deemed necessary that this be done as far as possible. These alterations to the machines have enabled the foundry to meet all the succeeding changes up to the present time, *i. e.*, so far as the moulding process is concerned.

The author next came to the introduction of chilled projectiles in the year 1866. The object of chilling, it is almost needless to say, is to insure penetration, and more especially the penetration of armor plates. In their first efforts in this direction, they arranged to cast the whole of the projectiles in an iron mould, but the results of the firing against armor plates proved the weakness rather than the strength of such a projectile, and the "entire chill" system was superseded by that which is now in use, viz., a iron-chilled point with sand-mould body. The chill was at first made in one piece, and a "chill" involved considerable trouble and

SPHERICAL COMMON SHELL. 26CWT

HAND GRENADE. 2 LBS.

expense. It was found necessary to turn it out to the proper curve form, leaving a clean surface. It was not unusual to find, where every precaution had not been observed, that the first cast would destroy it; and even with all the care possible, the life of a chill under these conditions was of short duration, a successful chill only standing from ten to fifteen casts before requiring renewal. It was felt that this expense must be reduced, and a proposal was made to bore the existing chills out sufficiently large to accept a lining. This proving a great success, the casting of the linings became a matter of interest. The moulding and casting of the linings are now executed with metal-turned patterns and every degree of care. The interior of the linings is not turned, as was the case in the solid chill, but left with the skin of the casting on. In order that the head of the projectile may be perfectly concentric with the recess in the body of the chill, which receives the body part of the moulding-box, the exterior of the lining is turned to fit exactly the body of the chill. They have thus insured two great advantages: First, the casting being light, they are enabled to get a much closer texture of iron in the lining than could be expected in the larger mass of the chill. Second, having the mould skin retained, they are enabled to get from forty to sixty casts out of the same chill; and when the chills are worn out, they are easily and quickly replaced. The introduction of the lining, however, presented a difficulty which, although since entirely overcome, is still of such importance as to deserve a passing notice. While aiming at keeping the point and body of the projectile mould perfectly concentric, the line formed between the chill and lining by virtue of unequal expansion and contraction gave room to particles of sand becoming embedded between, and a repetition of this evil, besides causing the point to be eccentric, resulted in the destruction of the lining, either by altering its form, or more generally breaking it. Altogether, it will be seen that a slight inclination or slope given to the outer lip of the lining acts in such a manner as to throw any sand to the surface or face of the sand mould without affecting either chill or mould. It is now proposed to supersede the studded projectile by one which shall be rotated by what is termed a "studded gas-check." The studs form a weak point in any projectile, more especially so in one intended for armor-piercing. The proposed shell will be cast with a peculiarly serrated base, which will do duty by sustaining the gas-check, which in its turn will be called upon to do the duty previously done by the studs. From 25 to 35 per cent. of the outturn is the most now used of Welsh iron. The remainder is made up of old guns, old shell, and the scrap produced in manufacture, a very ordinary mixture being:

	Per cent.
Welsh iron	30
Old spherical shell	30
Old guns	20
Scrap	20
	100

The author described at considerable length the plant in the foundry, and went on to deal with the statistics of output. The largest output of spherical shells of all sizes in one year—1859-60—was 1,937,000, or nearly two millions; and the weight of iron consumed in their manufacture irrespective of that melted for pig, etc , was nearly 20,000 tons. Since the introduction of elongated projectiles this quantity and amount has never been required; indeed, only such an exceptional period as the above could have necessitated such a demand, for it will be remembered we were entirely without stock of any kind, and wholly dependent on outside aid to furnish our requirements. Taking four ordinary years, it would be found that the average consumption of iron varies from 5,000 to 8,000 tons annually, and that a mean of the numbers of projectiles may be taken at a quarter of a million.—*The Engineer.*

THE MANUFACTURE OF MINERAL WOOL.

THE idea of utilizing blast-furnace slag by manufacturing from it a fibrous product called mineral wool in this country, originated in Germany, where Lürmann first arranged a plant at Osnabrück. For a number of years, it has been made on a working scale at a small blast furnace at Greenwood, N. Y., and the demand having grown, a second plant has been put in operation at Stanhope, N. J , which furnace delivers 20 slag cars per day to the parties making the wool. In many respects, present practice differs in detail from that first adopted and at the time described; and it may not be without interest to give some details, for which we are principally indebted to Mr. R. D. A. Parrott. The length and fineness of the fiber obtained by blowing steam across a stream of molten cinder depend largely upon the composition and temperature of the fluid material, a very liquid and hot cinder furnishing a larger percentage of very fine fiber, which it is the principal aim to produce. At Stanhope, steam under pressure of 45 to 80 pounds is allowed to escape from a crescent-shaped aperture, $1\frac{1}{2}$ inches by $\frac{1}{8}$ inch, and it strikes a stream of molten slag about a finger thick flowing from the cinder car over a gutter which controls the stream. The steam divides the slag into innumerable shot-like bodies, which in becoming detached, pull out a thread or fiber. The conversion is due entirely to the mechanical force of the particles of steam, which it is estimated travel at a speed of about 2,000 feet per second. They strike against a brick wall built up in a large chamber for collecting the wool. The shot are broken off from the fiber and lie embedded in the wool as it has settled upon the floor of the chamber. At Stanhope there are two of such chambers, into each of which four jets, arranged in pairs, deliver. While one of the chambers is in use, the other is being cleaned up, it having been allowed to cool off after blowing for half a day. The wool which is in these chambers, and which is intermixed with shot, is carried out of the chambers by a conveyer, run by a small engine to a riddle. It requires considerable agitation to get rid of the shot, and as much as six pounds to the cubic foot is got out. A conveyer takes away the riddled wool to the storehouse. About eighty per cent. of it is termed the ordinary grade of mineral wool, weighing about twenty-five pounds per cubic foot, while the other twenty per cent. is what the United States Mineral Wool Company call their "extra" grade, which is free from shot and weighs fifteen pounds per cubic foot. The currents of air created in the chamber by the steam jets carry the lightest fibers over the brick wall to a back chamber, where they accumulate and constitute the material for this finest grade. The riddle is a simple contrivance, consisting of a box about eight feet long, three feet wide, and two feet high, the top being covered with wire cloth having a one-quarter inch mesh. The box is suspended from above so that the surface of the screen is a little inclined, and is moved backward and forward rapidly by means of an eccentric wheel. Air is blown up through the screen by a Sturtevant fan, thus carrying away the fine dust. At present only a part of the cinder is utilized, as it chills. It is suggested that the building of a reverberatory furnace, into which the molten cinder from the blast-furnace is charged to be kept there until wanted, would give more regularity to the working, as it would act as a stock upon which it would be possible to draw at any time, and at the same time the cinder could always be made to have the proper temperature. The capacity of the present plant at Stanhope is about 2,000 pounds per day, and additional quantities could be made at the Greenwood furnace, Orange County, N. Y., if wanted.

Mineral wool is used chiefly as a non-conductor of heat, and the following tests made by Mr. C. E. Emery, and published in a paper read before the American Society of Mechanical Engineers, at their Hartford meeting, may be quoted to show its utility:

He recorded the results of a number of careful experiments on different non-conducting materials, the same acting as protectors of steam pipes. The experiments were made so as to present as nearly as possible the condition of steam pipes and their covering in practical use. Mr. Emery found that hair felt was the best non-conducting material. Taking the value of this at 100, he estimates the value of the other materials experimented with as follows:

Mineral wool, No. 2, two inches thick	83·02
Sawdust, two inches thick	68
Mineral wool, No. 1, two inches thick	67·60
Charcoal, two inches thick	63·20
Cross-cut pine, two inches thick	55·30
Loam, two inches thick	55
Asbestos, two inches thick	36·30
Air-space, two inches	13·60

Mr. Emery, in commenting upon the above results, calls attention to the poor showing of an air space, a result quite contrary to current popular opinion. He attributes the slight value of an air-space to the fact that connection of circulation takes place; that the air is cooled on one side of the space, descends and rises on the other, and it is necessary to break up the air-spaces, and that undoubtedly accounts for the efficiency of these different materials. He continues: "It is the air, probably, that is the non-conductor; but it should be kept quiescent instead of being allowed to circulate. The air-space itself is of very little value, until the circulation is prevented.—*Eng. and Min. Jour.*

REPRODUCTION OF NEGATIVES FOR SINGLE TRANSFER CARBON PRINTING.

By W. T. WILKINSON.*

NOTWITHSTANDING all the efforts to introduce double transfer carbon printing into general use as a substitute for the beautiful "but evanescent" silver print, especially for publication, photographers are almost unanimously of opinion that it neither pays, nor yields results such as will induce the public to accept carbon instead of silver. The reason of this is not far to seek. The process is too uncertain and tedious for commercial work, whether the temporary support be glass or flexible support, as when glass is used, except in very skilled hands, the chances are that less than 50 per cent. of the prints refuse to leave the old love for the new; and when flexible support is used, in addition to the difficulty of transferring, is the uncertainty whether during the development the print will stay in its place or blister up, these being without taking into account the bore of preparing the two supports. Certainly, if India-rubber paper be used for the temporary support, not only is the result better, but all these troubles are reduced to a minimum, except that the process is still tedious. Of course, we have often been told that the *raison d'etre* of the double transfer carbon process is merely to utilize the large stock of negatives already in the possession of photographers, and that the best results in carbon are only to be obtained by the single transfer process, which will give as good results as silver, and can be worked as economically and with as much certainty as silver. But then single transfer carbon requires what are called reversed negatives, and the question is, How are these to be obtained, and how are all the old negatives to be reversed? Certainly, all fresh negatives might be taken reversed by using a mirror, and the old ones stripped from the glass, but it would be manifestly awkward to have a stock of negatives some of which are reversed, and the rest not. As to stripping the films, that is far too uncertain and risky an operation to be thought of; therefore, for small orders, silver printing must be the method in use until another (for use with ordinary negatives) is introduced, giving results as good in quality, in economy, and certainty, but more permanent.

For publication or large orders, especially when required in a hurry, it is the practice to multiply the negative, making as many as required to get the orders off quickly; this being the case, why not make reversed negatives, and let the prints be by that simplest of processes, the single transfer carbon?

Some years ago Mr. Burton suggested that valuable negatives should never be subjected to the wear and tear of silver printing, but that a carbon transparency should be made, from which negatives for printing from are produced in the camera; but I would suggest that from the carbon transparency negatives be printed by contact upon gelatine bromide plates, with the aid of artificial light, when, by careful manipulation, any required number of exactly uniform negatives can be produced; and as such negatives are reversed, they are available for printing in carbon by the single transfer process.

Apart from any other advantage that may accrue from the facility with which negatives may be produced by this method, there is another which cannot be too highly estimated, and that is the opportunity offered of so greatly improving upon the quality of the original negative, because it does not always follow that the original negative is always good; it may be thin and flat, and yield anything but brilliant prints, with all the dodging that skill can bring to bear upon it. On the other hand, it may be so hard and dense, that even in the brightest sun, one print per diem is all that can be counted upon. Now, by the use of a suitable carbon tissue for making the transparency, both these defects can be overcome.

In both these cases, the tissue best adapted for making a suitable transparency is a thin fine tissue, such as is issued by the Autotype Co. for small portrait work, Nos. 113 and 114. For a thin negative the transparency must be printed just dark enough to show all detail well out, then intensified with permanganate of potash, or Mr. Burton's method with ammonia nitrate of silver, followed by pyrogallic and silver. When the original negative is very hard or dense, print as deep as possible, short of allowing the action to extend to paper supporting the tissue compound, while for good ordinary negatives the special transparency tissue will be found to be best for use.

A suitable transparency having been obtained, judicious retouching can be resorted to for its improvement. Spots and blemishes may be removed as minimizing the work upon the resulting print.

With regard to making the transparency, the simplest method of procedure is, after exposing the tissue for the requisite time under the negative, to polish a plate free from scratches, etc., and coat it with thin iodized collodion (previously filtered), and when the film has thoroughly set, place in cold filtered water; now, when the alcohol and ether have been eliminated, and the water flows evenly over the film, place the exposed tissue in the water, and at the proper time bring the two surfaces together under the water; lift out and place upon a flat surface, lay a piece of India-rubber cloth, or of single transfer paper previously wetted, over the plates, and apply the squeegee vigorously; then, after an interval of five or ten minutes, proceed to develop

* Read before the South London Photographic Society.

in warm water which is clean and free from floating particles.

Printing the negatives upon gelatine plates is best done by the light of a good paraffin lamp, such as a silber or a duplex, placing the printing frame about three feet away from the light, and when once the right exposure has been hit, as many negatives as may be required can be produced of exactly uniform quality, when they may be all printed together in one sheet, so minimizing the labor.

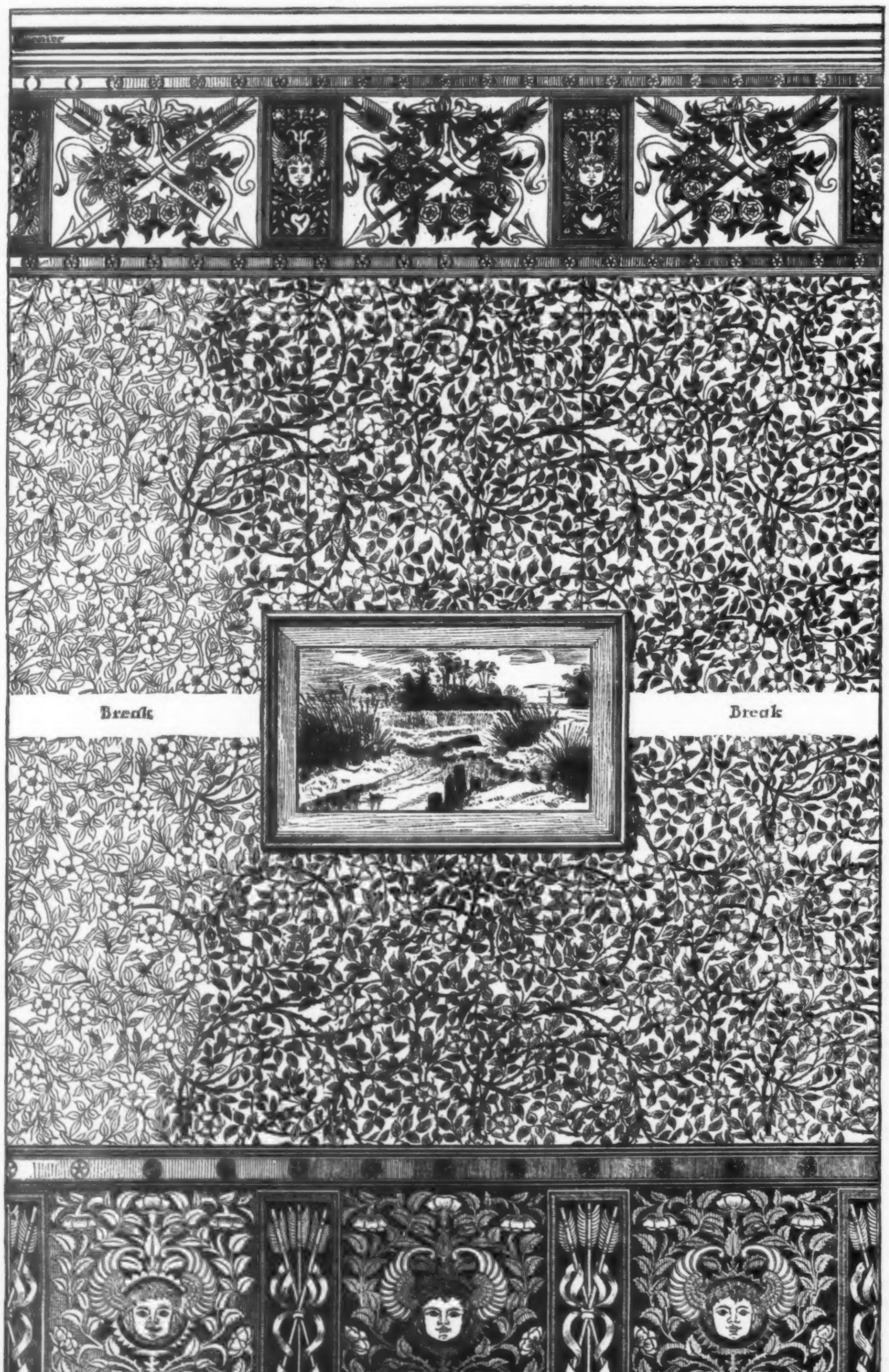
GAS PRESSURE IN THE SOLID COAL.

AN elaborate series of experiments on a subject upon which little that is definite is known has been conducted by Mr. Lindsay Wood, who has published them through the Transactions of the North of England Institute of Mining and Mechanical Engineers. With a view to ascertain the pressure of gas in the solid coal under varying conditions, Mr. Wood has bored holes at different depths into the coal in various seams at the Hetton, Elemore, Eppleton, Boldon, and Harton collieries, plugged the holes, applied gauges, and taken readings at regular intervals during long periods of time. The greatest pressure recorded is 461 pounds at the Boldon colliery, in a bore-hole 32 feet deep. In the same colliery, other observed pressures at various points were 176, 298, 381, and 425 pounds, thus showing considerable variations in the same seam. In the Elemore colliery, only 28 pounds were noted; while the figures were in the Hetton, 45 pounds; in the Eppleton, 31, 55, 104, 125, 204, 221, 223, and 235 pounds; and in the Harton colliery, 197, 231, and 295 pounds. The time elapsing before a maximum pressure was reached varied from one minute 14 seconds to attain 55 pounds in one of the holes of the Eppleton colliery, to 16 days 5 hours to come up to 235 pounds in the same vein of the same colliery. There does not seem to be any fixed relation between the pressure and the thickness of cover, as the highest of 461 pounds at the Boldon equaled 84 per cent. of that due to a column of water of the same height as the thickness of cover; in most cases, it scarcely reached 50 per cent. of the pressure due to the column, and in one instance it was only 8·75 per cent., the lowest pressures being obtained in the collieries that had been the longest opened out.

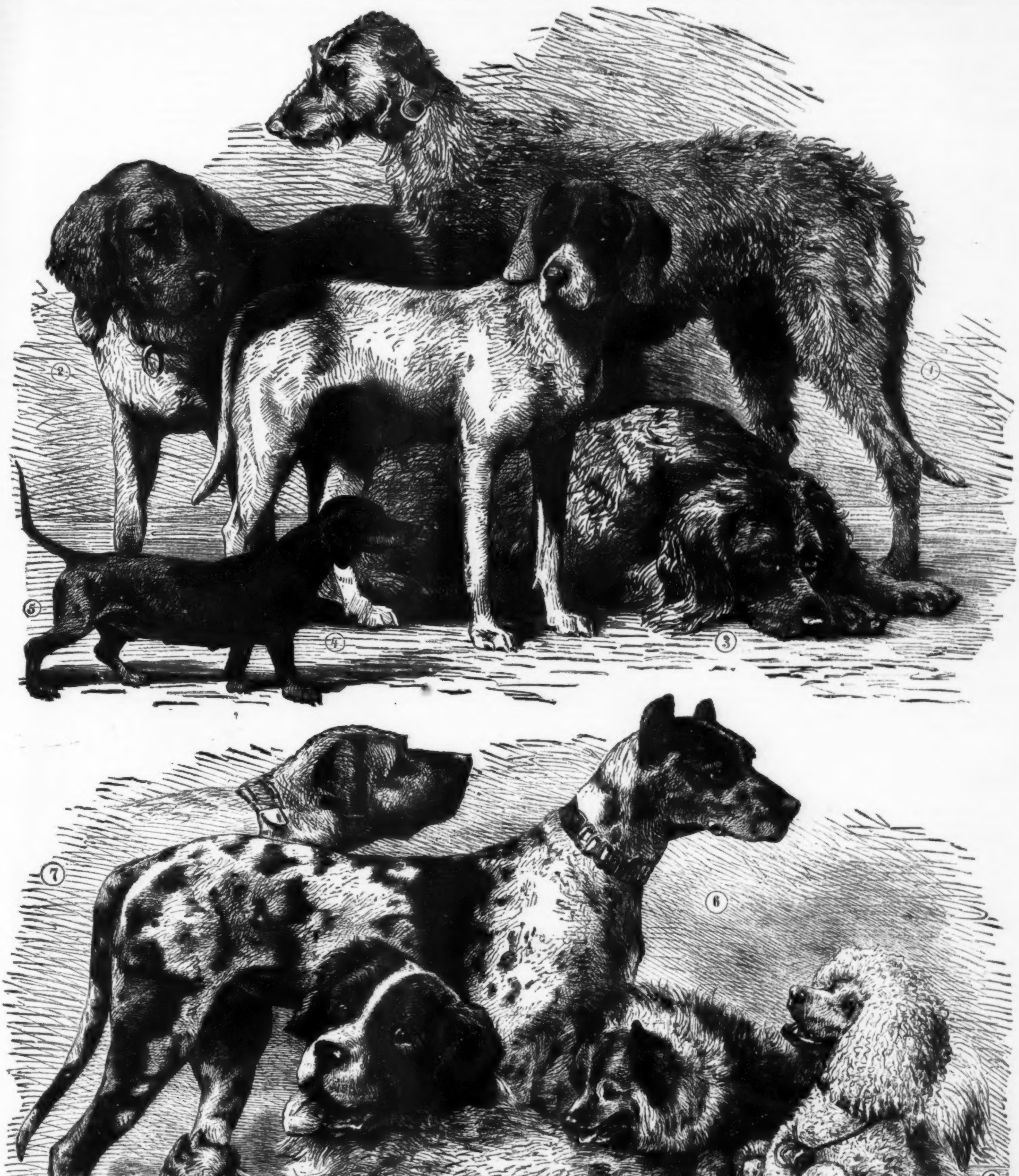
The maximum quantity of gas coming from one of the bore holes was 5·927 cubic feet per hour per square foot of hole surface; and the minimum, 0·057 cubic foot. The results of Mr. Wood's experiments show also that the variations of the barometrical column and the temperature have no observable effect upon the quantities of gas evolved.

ROSE PATTERN WALL-PAPER DECORATION.

WE illustrate the last new decorative design prepared for Messrs. Jeffrey & Co., of Essex road, Islington, by Mr. Walter Crane, who has thus described the design of the rose pattern: "'To those who have been long in city pent,' this wall-paper may perhaps help to recall the 'plaited alleys of the trailing rose' and other pleasurable places. The brier-rose on the wall is changed to the garden rose in the dado and frieze, having, in those positions, a more conventional form in accordance with the more strictly-defined limits of the pattern, as well as its figurative or emblematic intention. In the intermediate panels of the frieze and in the central panels of the dado, it will be noticed that the rose tree springs from a heart-shaped root (perhaps its native soil), and bears, for central flower, the winged head of an Amorius (a personage not altogether unconnected with its culture), while the crossed arrows through the garland point to the moral of the old song: 'When I gather the rose so red there groweth up a sharp thorn there.' The colorings are of the most delicate and harmonious kind, rendering the effect of the design hospitable in every way, and quite unobtrusive. This may be said equally of the executed work as of the original cartoon."—*Building News.*



SUGGESTIONS IN DECORATIVE ART.—ROSE PAPER, WALL DECORATION.



PRIZE ANIMALS AT THE INTERNATIONAL EXHIBITION OF DOGS, KLEVE, BELGIUM.

1. Scotch Deerhound, "Druamah."—2. English Bloodhound, "Hercules."—3. German long-haired Setter, "Job."—4. German short-haired Setter, "Cora."—5. Female Dachs-hund, "Longa."—6. German Tiger-dog, "Nero."—7. English Mastiff, "Prince."—8. Wolf Spitz-dog, "Mohr."—9. White curled-haired Poodle.—10. Alpine hound, "Gessler."—11. German Rough-haired Terrier, "Rattler."

[NATURE.]

PHENOMENA DEVELOPED BY HELIOSTATIC STAR-DISKS.

A HELIOSTAT of the highest class is doubtless beyond the means of ordinary observers, but such an instrument as the one now described is readily obtainable. Three sets of achromatic lenses forming a focal power of forty at ten inches, or a miniaturing power of one-fortieth, are in general sufficient. If formed into a microscopic object-glass, the front is turned toward the sun. The glass then refracts a beautifully small star-disk, which, owing to the large angular aperture of the combination, remains steadily in view for several hours. The optical characters of this disk vary considerably with the quality of the lenses; practically a very fine one-quarter by Powell and Lealand produces disks of remarkable beauty and precision. In some cases a plane mirror is conveniently attached to reflect the oblique solar rays.

The instrument thus provides a stationary solar star-disk for continuous observation. No clockwork or machinery is required. The size of the disk is one-fourth of the sine of the solar diameter, or nearly 45-10,000ths of an inch.

A more brilliant form of surpassing effulgence is occasionally employed by a 3-inch lens placed before a right-angled prism. An aerial image of the sun thus produced outshines the electric light. These disks are viewed at a distance of ten feet.

It is proposed to describe first their use in microscopic research, and secondly for telescopic vision.

I. MICROSCOPIC RESEARCH.

The Miniature Method.—A strong plate fitting the upper stage of the microscope by means of screws is pierced in the center by an aperture carrying the "societies" standard screw, into which an objective can be firmly screwed. The stage motions then give readily the necessary adjustments for coincidence of optical axes. This is called the *stage-holder.* All previous methods of fixing the objective in the sub-stage have been abandoned; the necessary steadiness being almost unattainable.

Phenomena of Heliostatic Star-Disks produced by the One-quarter.—Stage-holder armed with an inverted 1-32d water-immersion. The miniature of the star disk is now viewed microscopically with a 1-16th immersion. When both of these objectives are adjusted for the most brilliant vision, *distant foliage is distinctly visible.* A flag-staff carrying the Union Jack 180 yards away displays its double cross. The fine lightning-rod surmounting it is distinctly visible. Houses on a hill glisten in the sunshine; but conspicuous above all is the minute solar star-disk blazing with all the glory of a midday Sirius at the open window-sill.

Here the favorite tests for telescopic precision come richly into play. A minute brilliant bead surrounded by the most intensely black ring—the more wonderful as the brilliance seems to heighten its rare and beautiful delicacy and blackness—comes up and plays into expanding colored rings on each side of the principal focal point. (The delicate beauties of this exquisite phenomenon cannot well be seen without an exceedingly delicate fine focal adjustment.) The focusing wheel (constructed for the lightest contact) is divided into 132 parts; twenty-six give a focal plane the 1,000th of an inch deeper or higher, but a tenth part of this, or a change of focus of the 10,000th of an inch, changes the appearance of the magnified star-disk. These changes, so vivid and sudden, produce a lively impression of the minuteness of the wavelets of light which generate these diffractive phenomena.

The diameter of the brilliant disk, as miniatured, is about the 1-20,000th of an inch; the jet black ring in which it appears set, and indeed well set-off, is about 1-100,000th thick. Slight changes in the focus, but especially slight changes in the corrections of the observing and miniaturing glasses, produce a new order of phenomena, full of a significant meaning and practical import. The minimum visibile is perpetually forcing itself upon the observer's attention. The lightning-rod (here visible) 6,000 inches away, is miniatured 600 times smaller than at 10 inches by the 32d objective, which then would diminish an object only 320 times. The rod is, therefore, depicted nearly 200,000 times smaller. It is exactly half an inch in thickness; its size, therefore, in the miniature is 1-400,000th.

As the evening light faded away a long row of gas-lights reaching half a mile came into view in pretty perspective, the more distant being very slightly out of focus (six divisions). The 32d objective required to be advanced the 4,000th part of an inch for the distant light. In this case the miniature was produced by a Zeiss 1-32d, and viewed by another 32d by the same maker. The lowest eye-piece is employed and a shortened eye-tube. A single glance at these microscopic landscapes satisfies the observer at once as to the quality of the instruments of observation. Achromatism is seldom attained without generating a whitish haze, the inevitable accompaniment of residuary spherical aberration. This haze is an invaluable indication.

The haze observed in miniatures examined by high magnifying power is an invaluable indication of spherical residuary aberration. The method gives a cruel test of the optician's art. Its discovery led to the subject coming before the Royal Society and its being embodied in their Transactions. When first seen it was exhibited as a strong yellow fog. The announcement of it occasioned the greatest surprise to the distinguished makers of a "very fine" set for the writer. In most cases the higher the angular aperture the denser was seen the fog. The following is quoted: "Mechanical arrangements are shown by diagrams, Figs. 1, 1*a*, plate LII." (Phil. Tr., vol. ii. 1870, p. 592.)

"*Experiment I.*—Miniature of a small thermometer, the ivory scale being graduated 24° to the inch. A power of 300 diameters: low eyepiece 'A,' and objective of one-eighth focal length (made expressly for Podura testing) was applied to view the miniature formed by a one-sixteenth objective. The following appearances were carefully noted at the time of observation:

"*Result.*—The sparkle of light on the bulb of the instrument, the graduation, and the mercurial thread within the glass are invisible, obscured by a nebulous yellow fog which no objective adjustments are able to dissipate."

In consequence of this unexpected discovery regarding the quality of a "very fine" one-eighth, it was returned to the opticians, to their surprise, for better compensation. After improvements a very slight nebulous yellow cloud now only remained.

A new fact came up. A *miniature* formed by an imperfectly corrected glass is comparatively free from the aberration shown by the same glass used as a microscope. Thus, viewed by a good glass, the miniature of an inferior one bore wonderful magnification by an excellent objective.

In innumerable objects surface markings are shown only: with no perspective and with no foreshadow of deeper structures such objects are opaque. But if transparent, the foreshadow of deeper structures confuses the appearance of surface; strange eidola are generated difficult of interpretation and dispersion. A series of star-disks in deeper foci intermingle their diffractions into beautiful forms.

The strong fact that these diffractions of a given disk are wholly developed toward the eye of the observer, or wholly developed beyond the true focal plane, according as the correction of the glasses is over-wrought or under-wrought, reveals an infallible clew to many spurious effects. This method therefore more severely tests the observing instrumentation than the miniature.

The following experiment, arising out of the phenomena in course of observation, is quite a microscopic study in itself:

Experiment.—Miniature of garden view formed by a 1-30th plano convex lens and examined by a microscope armed with 1-8th giving 400 diameters.

Result.—Landscape dark and hazy. But upon using the same power (400) with a deep eyepiece and a half-inch objective, there started forth an exquisite picture brilliantly lit up. Even the foliage glittering in the sunlight was sharp, clear, and decisive, the details being marvelously displayed. This large increase of light with diminished observing angular aperture is at first sight astonishing.

It is to such causes doubtless that the microscopic world so long disputed whether the markings on diatoms were depressions or elevations. The earlier plates of such objects, as given by Quekett, teem with eidolic varieties of form. It was thought impossible to resolve them, as it was called, without complicated stops, which in fact shut off the unsuspected residuary aberration.

But it is necessary to pass to the *fundamental circular spectrum* of a minute solar disk. A simple plano-convex lens of half an inch focus is placed on the microscopic stage and made to form a miniature of the prism star in the field of the microscope. If the experiment be properly conducted, forty gorgeously colored rings may be counted. I have frequently examined these phenomena with a power of 1,000 diameters. Above the best focal point is a bright fog; below are seen the glorious diffractions. The sun, as far as it could be made out, was a spurious disk nearly 6-100,000ths of an inch; the first black ring, the blackest thing I ever beheld, was nearly the 1-50,000th. Each ring beyond appeared exactly of the same breadth—nearly the 1-16,000th.*

But it is when superb objectives are placed as it were eye to eye, that the finest observations can be made (especially when both are used with their noses inserted in the proper immersion fluid for observing landscapes) on distant objects.

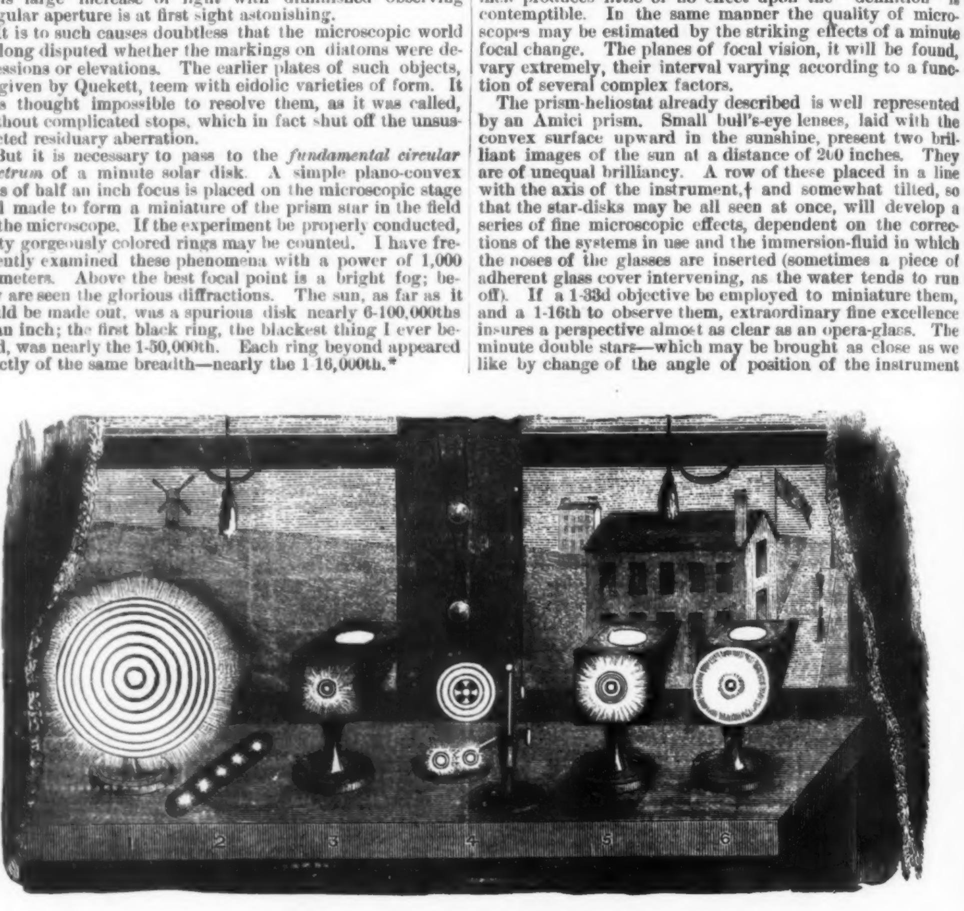
The extreme delicacy of the change in focal planes of vision is charmingly illustrated by observing with a good 1-8th the miniature of two brilliant points, the one 200 inches, the other 201 inches away in the same line. If the miniature is formed by a simple lens, theoretically the focal images of these star-disks would be separated by an interval of 2-10,000,000ths of an inch for a 1-10th lens, *perfectly* aplanatic.*

These disks, by their rapid change in appearance, give the most exquisite means of determining focal changes in the microscope. Thus for a focal depression of 7-10,000ths of an inch a change took place from *one* pure jet black diffraction-ring round central disk to eleven rings. The rings changed visibly for a focal depression of 100,000th of an inch.

The greatest confusion has existed regarding the terms penetration, definition, and resolution. The study of star disks miniatured by surpassingly well corrected glasses furnishes the observer with a new order of facts upon which irrefragable conclusions can be founded.

A telescope of very fine quality should have a focus of extreme delicacy. One whose change of focus by 1-10th of an inch produces little or no effect upon the "definition" is contemptible. In the same manner the quality of microscopes may be estimated by the striking effects of a minute focal change. The planes of focal vision, it will be found, vary extremely, their interval varying according to a function of several complex factors.

The prism-heliostat already described is well represented by an Amici prism. Small bull's-eye lenses, laid with the convex surface upward in the sunshine, present two brilliant images of the sun at a distance of 200 inches. They are of unequal brilliancy. A row of these placed in a line with the axis of the instrument,† and somewhat tilted, so that the star-disks may be all seen at once, will develop a series of fine microscopic effects, dependent on the corrections of the systems in use and the immersion-fluid in which the noses of the glasses are inserted (sometimes a piece of adherent glass cover intervening, as the water tends to run off). If a 1-33d objective be employed to miniature them, and a 1-16th to observe them, extraordinary fine excellence insures a perspective almost as clear as an opera-glass. The minute double stars—which may be brought as close as we like by change of the angle of position of the instrument



HELIOSTATIC STAR-DISKS.

FIG. 1.—Taking the objects from left to right, a representation is given of a miniature magnified a thousand times linear and the various appearances of the heliostatic star disks with slight changes of focusing. 1. Large diffraction rings: *fundamental spectrum* given by a plane convex lens ½ inch focal length placed on stage of microscope. Forty rings have been counted. 2. Optical gauge: various lenses showing spurious disks with minute diffraction rings similar to those on the "bull's-eye" in center of picture. 3. Intensely clear bright star disk produced by very perfect instrumentation. 4. A cross given by imperfect glasses. 5. Larger expanding rings, the miniature or observing glasses being either under or over-corrected. 6. The finest and clearest spurious disk attainable.

NOTE.—The house on the hill distinctly seen in this case of very finely corrected glasses. A miniature formed by a very fine 1-32d gives the distant house and window nearly in the same focal plane.

If now an over-corrected lens were substituted, the diffraction rings ascended and the nebulosity descended: they exactly changed positions as regards focimetry. The conclusion follows that all brilliant objects present diffractions above or below the true focus according as the observing instrument is over or under corrected by means of the usual screw collar adjustment.

In this way the same object, especially diatoms, may be made to take several very deceptive forms, because spuriously diffracted. The same is true of all brilliantly illuminated transparent structures

The intersection of an infinite number of cones of light converging to different points of the axis here produces the well-known interference extinction of undulation evolving precisely-formed rings of darkness. The simple lens, in these observations, develops circular spectra, as being formed by an infinite number of prisms.

An important outcome of this phenomenon is the unerring test (here presented by a simple single convex plane lens) of the highest possible order, as to the *quality* or inferiority of the observing microscope. Extreme steadiness and a *particularly* delicate fine focusing adjustment are indispensable for successful observations. It is impossible here to detail them.

A plane silvered mirror of the old style must be discarded as a solar reflector; prismatic internal reflection or reflection from a metallic surface is indispensable for producing purity of spectra.†

with the sun's azimuth—produce a variety of diffraction rings, mingling, crossing, and breaking up each other in a manner that could hardly be suspected during the telescopic observation of real double stars. Seldom can a bright landscape be attained without leaving some little outstanding color. If that be destroyed by changing the glasses or corrections immediately, *all black objects look gray*, and the gray becomes lighter as the color nearly vanishes. The rest of the view is charged with a thin grayish-white nebulosity, the sure indication—as already described—of residuary aberration. Just within the best focus an exquisite little dark-gray bead margined with black—much less than the primary brilliant disk (half its size)—may be discovered by close attention and a particularly well-adjusted focusing apparatus

In observing these interesting phenomena it will be seen that larger‡ and smaller spurious disks are formed according to the curvatures of the bull's-eyes; but there is one minimum size, and these, when contiguous, illustrate diffraction spectra in a brilliantly instructive form.§

* The contemplation of these phenomena, utterly eclipsing in their brilliant beauty and precision of form the fainter diffraction phenomena described by Sir John Herschel as among the most gorgeous in nature, astonishes every beholder. Some little skill is required in gradually toning down the excessive, I might say painful, glories of the appearances—lengthening the eye tube; glass tinted wedges (a single field-lens of a Huyghenian as eye-piece produced a spectrum apparently twelve inches in diameter, measured with the left eye by rule laid on the stage), or by camera.

† Some indications of quality in microscopes: (1) Confused mass of spurious disks oddly arranged; (2) Beauty of rings utterly marred; (3) Very few rings definable; (4) Spectrum notched, grained, and spotted; (5) Systems of eccentric rings dark and colored, much confused; (6) An "engine-turned pattern" mottled and degenerated; (7) Achromatism and freedom from spherical aberration in all cases found incompatible. The universal presence of some residuary spherical aberration is demonstrated by several irrefragable proofs in all the finest made modern glasses.

* First conjugate focus distance	0·10005002
Second " "	0·10004977
Interval between foci	0·00000025

† The miniature-making objective and observing microscope are both placed horizontally.

‡ Luckily the image of the sun is very nearly the hundredth part of the focal length of the lens employed. If a bull's-eye of 1-inch focal length be employed at 200 inches, and a miniature be produced by a 1-8th, diminishing it 20 × 80, or 1,600 times, the observed image of the sun would theoretically be 1-1,600 × 100 = 1-1,600,000 less than one millionth of an inch. It should be noted that if the primary axial image of the sun be too large, no diffraction spectra will be developed at 200 inches, unless very deep miniature-objectives be employed.

§ The January sun image formed by 1-inch lens is				1-106th inch.
The April	"	"	"	1-108th inch.
The July	"	"	"	1-109th inch.

Upon a proper arrangement, putting the bull's-eye and the instrument nearly in a line with the sun's azimuth, a superb representation of the double star, Castor, is seen, the fainter star being that caused by internal reflection. Intensely black diffraction rings round each, and several fainter ones, fewer as the quality of instrumentation is raised. Perfect roundness can only be attained by exact coincidence of the optical axes of the system. Very slight obliquity (even half a degree) causes the rings to overlap and bulge on one side. Much obliquity gives rise to glorious curves of the three orders of the conic sections, of wondrous beauty and precision in effulgent colors.

Mercurial globules near the microscope exhibit very delicate and complex forms when similarly miniatured, as minute solar disks, in sunlight.

Experiment.—An optician's gauge comprising half a dozen lenses of standard foci 1" to 1-6"th, lying in the sunshine, miniatured star-disks by reflection (see 1 in figure). Inferior objective 1½ inch examined with fine power of 1,000. Two brilliant crimson disks in contact expanding within focus to an oval ring of deep crimson beads.

Experiment.—If the image of the sun be received on white paper from a small lens placed at various degrees of obliquity peculiarly beautiful forms are seen fringed with color. When the lens is sufficiently minute these spectra exhibit to the microscope exquisitely arranged curves in jet-black lines; circular elliptic parabolic and hyperbolic, with inexhaustible variety, according to the focal plane of vision and obliquity. Heliostatic star-disks most successfully exhibit these unique phenomena. The superiority of these phenomena to anything telescopic of the sort is insured by the absence of atmospheric disturbance within so short a distance. They are all under instantaneous control.

The limits of human vision among so many bright points are patent enough. So long as there is bright sunshine every glittering point obscures, I might say utterly effaces, the finer traceries of detail. A passing cloud, however, brings them all out with astonishing fidelity. Brilliant diffraction is thus demonstrated to be incompatible with exact portraiture. The limit is reached in brilliant sunshine by the diffraction disks obliterating the very objects which produce them. This limit is well measured by the diameter of the smaller disks seen in contact, which in white compound light generally appears by micrometric measurement to be between the 1-80,000th and 120,000th of an inch in the microscopic field.

We need not be surprised at this variation: the undulatory theory of light gives *one* size only. Yet, as the spurious disk by theory is shaded off *gradually* into the first intensely black first ring, fainter stars telescopically show smaller disks.

But while a close row of spurious disks are seen to coalesce and obliterate themselves if too close, and become continuous as a thick luminous line—the necessary effect of bright diffractions—duller objects devoid of brilliance are seen of amazing minuteness of tracery.

Example.—The rungs or rounds of a ladder resting against a house half a mile off were distinctly seen when miniatured down to 1-1,000,000th of their actual size, *i. e.*, considerably less than 1-1,000,000th of an inch. This feat was accomplished by an immersion 1-32d by Seibert, which diminishes an object 30,000 inches away just about 1,000,000 times. The bane of minute microscopic research is thus seen to essentially consist of a combination of diffraction with the haze of aberration.

A blue glass evidently diminishes the diffraction phenomena; so do neutral tints. This exactly tallies with the shrinking of spurious telescopic disks during haze and sky-clouding. These facts forcibly point out the great advantages of observing in mild light. In further support of this the writer has thus effected several very difficult resolutions—in the "Ultima Thule" of microscopic investigation glare is the prolific parent of many fallacious interpretations.

These studies have encouraged the writer to continue a research into the limits of human microscopic vision. In the case of bright illuminations the limit is evidently reached at once. A minute refracting spherule thus forms a bright focal point which itself exceeds by expansion into a spurious disk, the diameter of the spherule producing it. Down to a certain size a focal image is discernible. A very interesting study is given by the solar star-disks presented by receiving the rays from the heliostat after passing through a beetle's eye placed on the field of view on the stage of the microscope. Until the sun shone the window appeared miniatured in each eye. It seems curious to measure the focal length. By measuring the images this was found to be 1-1,000th of an inch, giving enormous magnification for ordinary vision.* The solar disk, however, appeared spuriously enlarged.

More wonderful diffraction-phenomena are developed by different treatment. A half inch condenser-objective was inserted between the coleopterous eyes and the heliostat—behind or beyond the stage. The solar disks developed then appeared severely beautiful. No such wonderfully sharp black rings are even viewed telescopically. These phenomena are in order of focal classes:

1. Intensely black truly formed rings.
2. Hexagonal black patterns on a brilliant ground.
3. Three such hexagonal rings to each eye-facet.
4. Five such finished off with extremely rich Scotch plaid patterns, highly colored.

G. W. ROYSTON-PIGOTT.

* Their focal length was measured by selecting a well defined object, as a red brick house, carefully measuring micrometically a given part of it, and then measuring an image of the same thing in a known lens.

If d be the distance of the object from its image, m the size of its miniature, M the size of the object,

$$f = d \times m \div M.$$

A convenient formula for estimating the focal length of a small lens was given me in the Phil. Trans. If it is found to magnify m times at a distance *between object and image*, d, and if m be considerable,

$$f = \frac{d}{m+2}, \text{ more accurately } = \frac{d}{m + \frac{1}{m} + 2}$$

NEW SUCTION AND PRESSURE APPARATUS.

By DR. ROBERT MUENCKE, of Berlin.

IF the mixture of water and air, which flows from the ordinary water-jet pumps ("rapid filters") in laboratories, is caught in a reservoir of such construction that the air may escape above, and the water below, it will be found that the air will be expelled with more or less energy, in proportion to the quantity of air carried down and to the shape and construction of the cylinder in which the mixture of air and water are allowed to separate. If the pump is so constructed that, with a consumption of 9 to 10 liters of water, it aspirates about 15 to 20 liters of air per minute, and if it is connected with a reservoir of proper size, there will be obtained a blast of compressed air, which, when issuing from a jet of 2 mm. in diameter, and with a water-pressure of 2 to 3 atmospheres, equals a column of mercury of 22 cm., and therefore is sufficiently strong to supply a large blast-lamp.

The complete apparatus consists, in general, of two main portions; namely, the pump, B, and the reservoir, A. The pump itself consists of three pieces, B, *c*, *d*, adjustable by screws, of which the upper part, B, contains the upper cone of the water-jet, and also the lateral tube, *b*, for conveying the aspirated air. B is connected with the stuffing-box, *c*, which may be screwed higher and lower, and in which the tube, *d*, containing the lower cone, is likewise adjustable by screw-thread. The pump is screwed, by means of the nut, *e*, centrally upon the top of the reservoir, A, while its upper end is connected by means of a rubber-tube, *a a*, with the water-supply (*h* represents a style of water-valve). Near

MUENCKE'S SUCTION AND PRESSURE APPARATUS.

the edge of the top of the reservoir is a faucet and nipple, through which the compressed air escapes, and the water flows off below at K.

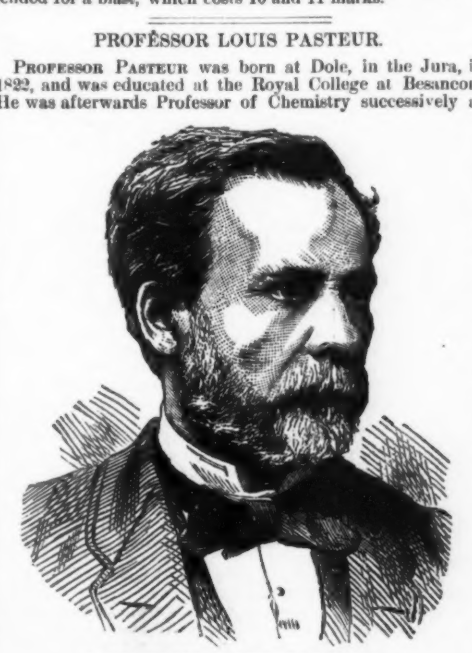
When using the apparatus, the joint, *d*, is at first screwed as far as possible into the piece, B. Next the faucet at *g* is closed, the outlet at *k* opened, and the water turned on at *h*. The joint, *d*, together with the reservoir with which it must be connected perfectly tight, is then gradually screwed downward, until a vacuum-gauge, connected with *b*, indicates the maximum of exhaustion. If the connection at *b* be now removed (that is, if air be freely admitted) the faucet at *g* be opened, and the outlet at *k* be regulated so that the water will flow off unmixed with air, and that it will maintain a constant level in the reservoir—there will be obtained a blast of air equal to about 22 cm. of mercury, as stated above. In order to prevent a projection of water from the tube, *b*, at the time of setting the apparatus at rest, it is necessary to turn off the water-supply at *h* very gradually.

When using the apparatus as an aspirator, it is absolutely necessary to keep the faucet, *g*, closed, and to always turn off the connection between the pump and the rarefied vessel, before shutting off the water.

The price of the apparatus as shown in the cut is 27·50 *marks*; provided with additional fittings, such as vacuum-gauge, pressure-gauge, etc., the prices are 30, 40, 42·50, and 57·50 marks. There is also a more simple kind, only intended for a blast, which costs 10 and 11 marks.

PROFESSOR LOUIS PASTEUR.

PROFESSOR PASTEUR was born at Dole, in the Jura, in 1822, and was educated at the Royal College at Besancon. He was afterwards Professor of Chemistry successively at



PROFESSOR LOUIS PASTEUR.

Dijon and Strassburg. In 1857 he was made director of Scientific Studies at the Higher Normal School in Paris, and since 1868 he has been Director of the Chemical and Physiological Laboratory attached to the *Ecole des Hautes Etudes* in that city. He has won innumerable prizes, and is a fellow of various scientific bodies, native and foreign, but our chief business with him here is in his character as an animal vaccinator. As Sir James Paget remarked, he has done for the lower animals that which Jenner had already done for the human race. In France there die every year by splenic fever (*charbon*) animals worth £800,000. Professor Pasteur has discovered a safeguard against this plague. He inoculates animals with the splenic virus artificially prepared, or, to use his own phrase, "cultivated." He has found that by allowing certain intervals of time to elapse between the impregnation of the "virus-cultures" he can regulate the strength of the poison, he can attenuate it till, instead of producing death, it acts, like the vaccine lymph among mankind, as a prophylactic against death. In his address before the International Medical Congress, on August 8, Professor Pasteur says: "I was asked to give a public demonstration of the results obtained. Fifty sheep were placed at my disposition, of which twenty-five were vaccinated. A fortnight afterward the fifty sheep were inoculated with the most virulent anthracoid microbe. The twenty-five vaccinated sheep resisted the infection, the twenty-five unvaccinated died of splenic fever within fifty hours. Since that time my energies have been taxed to meet the demands of farmers for supplies of this vaccine." The Professor added: "May we not here be in presence of a general law applicable to all kinds of virus?" Speaking of these discoveries Professor Huxley says: "They fully balance the ransom of £200,000,000 paid by France to Germany after the war of 1870–71."

In SCIENTIFIC AMERICAN SUPPLEMENT, No. 300, Oct. 1, 1881, we gave in extenso a very remarkable address, recently delivered by Professor Pasteur before the International Medical Congress, in which some of his wonderful discoveries are outlined. Our portrait, for which we are indebted to the *Graphic*, is from a photograph by E. Ladrey, Boulevard des Italiens, Paris.

ON THE DISCOVERIES OF THE PAST HALF-CENTURY RELATING TO ANIMAL MOTION.*

By J. BURDON-SANDERSON, M.D., LL.D., F.R.S., Professor of Physiology in University College, London.

THE two great branches of biology with which we concern ourselves in this section, animal morphology and physiology, are most intimately related to each other. This arises from their having one subject of study—the living animal organism. The difference between them lies in this, that whereas the studies of the anatomist lead him to fix his attention on the organism itself, to us physiologists it, and the organs of which it is made up, serve only as *vestigia*, by means of which we investigate the vital processes of which they are alike the causes and consequences.

To illustrate this I will first ask you to imagine for a moment that you have before you one of those melancholy remainders of what was once an animal—to wit, a rabbit—which one sees exposed in the shops of poulterers. We have no hesitation in recognizing that remainder as being in a certain sense a rabbit; but it is a very miserable vestige of what was a few days ago enjoying life in some wood or warren, or more likely on the sand-hills near Ostend. We may call it a rabbit if we like, but it is only a remainder—not the thing itself.

The anatomical preparation which I have in imagination placed before you, although it has lost its inside and its outside, its integument and its viscera, still retains the parts for which the rest existed. The final cause of an animal, whether human or other, is muscular action, because it is by means of its muscles that it maintains its external relations. It is by our muscles exclusively that we act on each other. The articulate sounds by which I am addressing you are but the results of complicated combinations of muscular contractions—and so are the scarcely appreciable changes in your countenances by which I am able to judge how much, or how little, what I am saying interests you.

Consequently the main problems of physiology relate to muscular action, or, as I have called it, animal motion. They may be divided into two—namely (1), in what does muscular action consist—that is, what is the process of which it is the effect or outcome? and (2), how are the motions of our bodies co-ordinated or regulated? It is unnecessary to occupy time in showing that, excluding those higher intellectual processes which, as they leave no traceable marks behind them, are beyond the reach of our methods of investigation, these two questions comprise all others concerning animal motion. I will, therefore, proceed at once to the first of them—that of the process of muscular contraction.

The years which immediately followed the origin of the British Association exceeded any earlier period of equal length in the number and importance of the new facts in morphology and in physiology which were brought to light; for it was during that period that Johannes Müller, Schwann, Henle, and, in this country, Sharpey, Bowman, and Marshall Hall, accomplished their productive labors. But it was introductory to a much greater epoch. It would give you a true idea of the nature of the great advance which took place about the middle of this century if I were to define it as the epoch of the death of "vitalism." Before that time, even the greatest biologist—*e. g.*, J. Müller—recognized that the knowledge they possessed both of vital and physical phenomena was insufficient to refer both to a common measure. The method, therefore, was to study the process of life in relation to each other only. Since that time it has become fundamental in our science not to regard any vital process as understood at all, unless it can be brought into relation with physical standards, and the methods of physiology have been based exclusively on this principle. Let us inquire for a moment what causes have conduced to the change.

The most efficient cause was the progress which had been made in physics and chemistry, and particularly those investigations which led to the establishment of the doctrine of the conservation of energy. In the application of this great principle to physiology, the men to whom we are indebted are, first and foremost, J. R. Mayer, of whom I shall say more immediately; and secondly, to the great physiologists still living and working among us, who were the pupils of J. Müller—viz., Helmholtz, Ludwig, Du Bois Reymond, and Brücke.

As regards the subject which is first to occupy our attention, that of the *process* of muscular contraction, J. R. Mayer occupies so leading a position that a large proportion of the researches which have been done since the new era, which he had so important a share in establishing, may be rightly considered as the working out of principles enunciated in his treatise† on the relation between organic motion and exchange of material. The most important of these were, as expressed in his own words: (1) "That the chemical force contained in the ingested food and in the inhaled oxygen is the source of the motion and heat which are the

* Opening address in the Department of Anatomy and Physiology, British Association, 1881, York.

† J. R. Mayer, "Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel: ein Beitrag zur Naturkunde," Heilbronn, 1845.

two products of animal life; and (2) that these products vary in amount with the chemical process which produces them." Whatever may be the claims of Mayer to be regarded as a great discoverer in physics, there can be no doubt that as a physiologist he deserves the highest place that we can give him, for at a time when the notion of the correlation of different modes of motion was as yet very unfamiliar to the physicist, he boldly applied it to the phenomena of animal life, and thus reunited physiology with natural philosophy, from which it had been rightly, because unavoidably, severed by the vitalists of an earlier period.

Let me first endeavor shortly to explain how Mayer himself applied the principle just enunciated, and then how it has been developed experimentally since his time.

The fundamental notion is this: the animal body resembles, as regards the work it does and the heat it produces, a steam-engine, in which fuel is continually being used on the one hand, and work is being done and heat produced on the other. The using of fuel is the chemical process, which in the animal body, as in the steam-engine, is a process of oxidation. Heat and work are the useful products, for, as, in the higher animals, the body can only work at a constant temperature of about 100° F., heat may be so regarded.

Having previously determined the heat and work severally producible by the combustion of a given weight of carbon, from his own experiments and from those of earlier physicists, Mayer calculated that if the oxidation of carbon is assumed to represent approximately the oxidation process of the body, the quantity of carbon actually burnt in a day is far more than sufficient to account for the day's work, and that of the material expended in the body not more than one-fifth was used in the doing of work, the remaining four-fifths being partly used, partly wasted in heat production.

Having thus shown that the principles of the correlation of process and product hold good, as far as its truth could then be tested, as regards the whole organism, Mayer proceeded to inquire into its applicability to the particular organ whose function it is "to transform chemical difference into mechanical effect"—namely, muscle. Although, he said, a muscle acts under the direction of the will, it does not derive its power of motion from the will any more than a steamboat derives its power of motion from the helmsman. Again (and this was of more importance, as being more directly opposed to the prevalent vitalism), a muscle, like the steamboat, uses in the doing of work, not the material of its own structure or mechanism, but the fuel—*i. e.*, the nutriment—which it derives directly from the blood which flows through its capillaries. "The muscle is the instrument by which the transformation of force is accomplished, not the material which is itself transformed." This principle he exemplified in several ways, showing that if the muscle of our bodies worked, as was formerly supposed, at the expense of their own substance, their whole material would be used up in a few weeks, and that in the case of the heart, a muscle which works at a much greater rate than any other, it would be expended in as many days—a result which necessarily involved the absurd hypothesis that the muscular fibers of our hearts are so frequently disintegrated and reintegrated that we get new hearts once a week.

On such considerations Mayer founded the prevision, that, as soon as experimental methods should become sufficiently perfect, to render it possible to determine with precision the limits of the chemical process either in the whole animal body or in a single muscle during a given period, and to measure the production of heat and the work done during the same period, the result would show a quantitative correlation between them.

If the time at our disposal permitted, I should like to give a short account of the succession of laborious investigations by which these previsions have been verified. Begun by Bidder and Schmidt in 1851,* continued by Pettenkofer and Voit,† and by the agricultural physiologists‡ with reference to herbivora, they are not yet by any means completed. I must content myself with saying that by these experiments the first and second parts of this great subject—namely, the limits of the chemical process of animal life and its relation to animal motion under different conditions—have been satisfactorily worked out, but that the quantitative relations of heat production are as yet only insufficiently determined.

Let me sum up in as few words as possible how far what we have now learnt by experiment justifies Mayer's anticipations, and how it falls short of or exceeds them. First of all, we are as certain as of any physical fact that the animal body in doing work does not use its own material—that, as Mayer says, the oil to his lamp of life is food; but in addition to this we know what he was unaware of, that what is used is not only not the living protoplasm itself, but is a kind of material which widely differs from it in chemical properties. In what may be called commercial physiology—*i. e.*, in the literature of trade puffs—one still meets with the assumption that the material basis of muscular motion is nitrogenous; but by many methods of proof it has been shown that the true "Oel in der Flamme des Lebens" is not proteid substance, but sugar, or sugar-producing material. The discovery of this fundamental truth we owe first to Bernard (1850–56), who brought to light the fact that such material plays an important part in the nutrition of every living tissue; secondly, to Voit (1866), who in elaborate experiments on carnivorous animals, during periods of rest and exertion, showed that, in comparing those conditions, no relation whatever shows itself between the quantity of proteid material (flesh) consumed, and the amount of work done; and finally to Frankland, Fick, and his associate, Wislicenus, as to the work-yielding value of different constituents of food, and as to the actual expenditure of material in man during severe exertion. The subjects of experiment used by the two last-mentioned physiologists were themselves; the work done was the mountain ascent from Interlaken to the summit of the Faulhorn; the result was to prove that the quantity of material used was proportional to the work done, and that that material was such as to yield water and carbonic acid exclusively.

The investigators to whom I have just referred aimed at proving the correlation of process and product for the whole animal organism. The other mode of inquiry proposed by Mayer, the verification of his principle in respect of the work-doing mechanism—that is to say, in respect of muscle taken separately—has been pursued with equal perseverance during the last twenty years, and with greater success; for in experimenting on a separate organ, which has no other functions excepting those which are in question, it is possible to eliminate uncertainties which are unavoidable when the conditions of the problem are more complicated. Before I attempt to sketch the results of these experiments, I must ask your attention for a moment to the discoveries made since Mayer's epoch, concerning a closely related subject, that of the process of respiration.

I wish that I had time to go back to the great discovery of Priestley (1776), that the essential facts in the process of respiration are the giving off of fixed air, as he called it, and the taking in of dephlogisticated air, and to relate to you the beautiful experiments by which he proved it; and then to pass on to Lavoisier (1777), who, on the other side of the Channel, made independently what was substantially the same discovery a little after Priestley, and added others of even greater moment. According to Lavoisier, the chemical process of respiration is a slow combustion which has its seat in the lungs. At the time that Mayer wrote, this doctrine still maintained its ascendency, although the investigations of Magnus (1838) had already proved its fallacy. Mayer himself knew that the blood possessed the property of conveying oxygen from the lungs to the capillaries, and of conveying carbonic acid gas from the capillaries to the lungs, which was sufficient to exclude the doctrine of Lavoisier. Our present knowledge of the subject was attained by two methods—viz., first, the investigation of the properties of the coloring matter of the blood, since called "hæmoglobin," the initial step in which was made by Prof. Stokes in 1862; and secondly, the application of the mercurial air-pump as a means of determining the relations of oxygen and carbonic acid gas to the living blood and tissues. The last is a matter of such importance in relation to our subject that I shall ask your special attention to it. Suppose that I have a barometer of which the tube, instead of being of the ordinary form, is expanded at the top into a large bulb of one or two liters capacity, and that, by means of some suitable contrivance, I am able to introduce, in such a way as to lose no time and to preclude the possibility of contact with air, a fluid ounce of blood from the artery of a living animal into the vacuous space—what would happen? Instantly the quantity of blood would be converted into froth, which would occupy the whole of the large bulb. The color of the froth would at first be scarlet, but would speedily change to crimson. It would soon subside, and we should then have the cavity which was before vacuous occupied by the blood and its gases—namely, the oxygen, carbonic acid gas, and nitrogen previously contained in it. And if we had the means (which actually exist in the gas-pump) of separating the gaseous mixture from the liquid, and of renewing the vacuum, we should be able to determine (1) the total quantity of gases which the blood yields, and (2), by analysis, the proportion of each gas.

Now, with reference to the blood, by the application of the "blood-pump," as it is called, we have learnt a great many facts relating to the nature of respiration, particularly that the difference of venous from arterial blood depends not on the presence of "effete matter," as used to be thought, but on the less amount of oxygen held by its coloring matter, and that the blood which flows back to the heart from different organs, and at different times, differs in the amount of oxygen and of carbonic acid gas it yields, according to the activity of the chemical processes which have their seat in the living tissues from which it flows.* But this is not all that the blood-pump has done for us. By applying it not merely to the blood, but to the tissues, we have learnt that the doctrine of Lavoisier was wrong, not merely as regards the place, but as regards the nature of the essential process in respiration. The fundamental fact which is thus brought to light is this, that although living tissues are constantly and freely supplied with oxygen, and are in fact constantly tearing it from the hæmoglobin which holds it, yet they themselves yield no oxygen to the vacuum. In other words, the oxygen which living protoplasm seizes upon with such energy that the blood which flows by it is compelled to yield it up, becomes so entirely part of the living material itself that it cannot be separated even by the vacuum. It is in this way only that we can understand the seeming paradox that the oxygen, which is conveyed in abundance to every recess of our bodies by the blood stream, is nowhere to be found. Notwithstanding that no oxidation-product is formed, it becomes latent in every bit of living protoplasm; stored up in quantity proportional to its potential activity—*i. e.*, to the work, internal or external, it has to do.

Thus you see that the process of tissue respiration—in other words, the relation of living protoplasm to oxygen—is very different from what Mayer, who localized oxidation in the capillaries, believed it to be. And this difference has a good deal to do with the relation of process to product in muscle. Let us now revert to the experiments on this subject which we are to take as exemplification of the truth of Mayer's forecasts.

The living muscle of a frog is placed in a closed chamber which is vacuous—*i. e.*, contains only aqueous vapor. The chamber is so arranged that the muscle can be made to contract as often as necessary. At the end of a certain period it is found that the chamber now contains carbonic acid gas in quantity corresponding to the number of contractions the muscle has performed. The water which it has also given off cannot of course be estimated. Where do these two products come from? The answer is plain. The muscle has been living all the time, for it has been doing work, and (as we shall see immediately) producing heat. What has it been living on? Evidently on stored material. If so, of what nature? If we look for the answer to the muscle, we shall find that it contains both proteid and sugar-producing material, but which is expended in contraction we are not informed. There is, however, a way out of the difficulty. We have seen that the only chemical products which are given off during contraction are carbonic acid gas and water. It is clear, therefore, that the material on which it feeds must be something which yields, when oxidized, these products, and these only. The materials which are stored in muscle are oxygen and sugar, or something resembling it in chemical composition.

And now we come to the last point I have to bring before you in connection with this part of my subject. I have assumed up to this moment that heat is always produced when a muscle does work. Most people will be ready to admit as evidence of this, the familiar fact that we warm ourselves by exertion. This is in reality no proof at all.

The proof is obtained when, a muscle being set to contract, it is observed that at each contraction it becomes warmer. In such an experiment, if the heat capacity of muscle is known, the weight of the particular muscle, and the increase of temperature, we have the quantity of heat produced.

If you determine these data in respect of a series of contractions, arranging the experiments so that the work done in each contraction is measured, and immediately thereupon reconverted into heat, the result gives you the total product of the oxidation process in heat.

If you repeat the same experiment in such a way that the work done in each contraction is not so reconverted, the result is less by the quantity of heat corresponding to the work done. The results of these two experiments have been found by Prof. Fick to cover each other very exactly. I have stated them in a table* in which we have the realization as regards a single muscle of the following forecast of Mayer's as regards the whole animal organism. "Convert into heat," he said, "by friction or otherwise, the mechanical product yielded by an animal in a given time, add thereto the heat produced in the body directly during the same period, and you will have the total quantity of heat which corresponds to the chemical processes.' We have seen that this is realizable as regards muscle, but it is not even yet within reach of experimental verification as regards the whole animal.

I now proceed abruptly (for the time at our disposal does not admit of our spending it on transitions) to the consideration of the other great question concerning vital motion, namely, the question how the actions of the muscles of an animal are so regulated and so ordinated as to determine the combined movements, whether rhythmical or voluntary, of the whole body.

As every one knows who has read the "Lay Sermons," the nature and meaning of these often unintentional, but always adapted motions, which constitute so large a part of our bodily activity, was understood by Descartes early in the seventeenth century. Without saying anything as to his direct influence on his contemporaries and successors, there can be no doubt that the appearance of Descartes was coincident with a great epoch—an epoch of great men and great achievements in the acquirement of man's intellectual mastery over nature. When he interpreted the unconscious closing of the eyelids on the approach of external objects, the acts of coughing, sneezing, and the like as mechanical and reflected processes, he neither knew in what part of the nervous system the mechanisms concerned were situated, nor how they acted? It was not until a hundred years after that Whytt and Hales made the fundamental experiments on beheaded frogs, by which they showed that the involuntary motions which such preparations execute cease when the whole of the spinal cord is destroyed—that if the back part of the cord is destroyed, the motions of the hind limbs, if the fore part, those of the fore limbs, cease. It was in 1751 that Dr. Whytt published in Edinburgh his work on the involuntary motions of animals. After this the next great step was made within the recollection of living physiologists: a period to which, as it coincided with the event which we are now commemorating—the origin of the British Association—I will now ask your special attention.

Exactly forty-nine years ago Dr. Marshall Hall communicated to the Zoological Society of London the first account of his experiments on the reflex function of the spinal cord. The facts which he had observed, and the conclusions he drew from them, were entirely new to him, and entirely new to the physiologists to whom his communication was addressed. Nor can there be any reason why the anticipation of his fundamental discovery by Dr. Whytt should be held to diminish his merits as an original investigator. In the face of historical fact it is impossible to regard him as the discoverer of the "reflex function of the spinal cord," but we do not the less owe him gratitude for the application he made of the knowledge he had gained by experiments on animals to the study of disease. For no one who is acquainted with the development of the branch of practical medicine which relates to the diseases of the central nervous system will hesitate in attributing the rapid progress which has been made in the diagnosis and treatment of these diseases to the impulse given by Dr. Marshall Hall to the study of nervous pathology.

In the mind of Dr. Marshall Hall the word reflex had a very restricted meaning. The term "excito-motory function," which he also used, stood in his mind for a group of phenomena of which it was the sole characteristic that a sensory impression produced a motor response. During the thirty years which have elapsed since his death, the development of meaning of the word reflex has been comparable to that of a plant from a seed. The original conception of reflex action has undergone not only expansion, but also modification, so that in its wider sense it may be regarded as the empirical development of the philosophical views of the animal mechanism promulgated by Descartes. Not that the work of the past thirty years by which the physiology of the nervous system has been constituted can be attributed for a moment to the direct influence of Descartes. The real epoch-maker here was Johannes Müller. There can be no doubt that Descartes' physiological speculations were well known to him, and that his large acquaintance with the thought and work of his predecessors conduced, with his own powers of observation, to make him the great man that he was; but to imagine that his ideas of the mechanism of the nervous system were inspired, or the investigations by which, contemporaneously with Dr. Marshall Hall, he demonstrated the fundamental facts of reflex action, were suggested by the animal automatism of Descartes, seems to me wholly improbable.

I propose, by way of conclusion, to attempt to illustrate the nature of reflex action in the larger sense, or, as I should prefer to call it, the automatic action of centers, by a single example—that of the nervous mechanism by which the circulation is regulated.

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* Bidder and Schmidt, "Die Verdauungssäfte und der Stoffwechsel," Leipsic, 1852.

† Pettenkofer and Voit, *Zeitschr. f. Biologie*, passim, 1866-80.

‡ Henneberg and Stohmann, "Beiträge zur Begründung einer rationellen Futterung der Wiederkäuer," Brunswick and Göttingen, 1860-70.

* Ludwig's first important research on this subject was published in 18 .

* RELATION OF PRODUCT AND PROCESS IN MUSCLE.

(Result of one of Fick's experiments.)

Mechanical product	6670·0	grammemillimeters.
Its heat-value	15·6	milligrammeunits.
Heat produced	39·0	"
Total product reckoned as heat	54·6	"

† Descartes' scheme of the central nervous mechanism comprised all the parts which we now regard as essential to "reflex action." Sensory nerves were represented by threads (filets) which connected all parts of the body to the brain ("Œuvres," par V. Cousin, vol. iv. p. 359); motor nerves by tubes which extended from the brain to the muscles; "motor centers" by "pores" which were arranged on the internal surface of the ventricular cavity of the brain and guarded the entrances to the motor tubes. This cavity was supposed to be kept constantly charged with "animal spirits" furnished to it from the heart by arteries specially destined for the purpose. Any "incitation" of the surface of the body by an external object which affects the organs of sense does so, according to Descartes, by producing a *motion* at the incited part. This is communicated to the pore by the thread, and causes it to open, the consequence of which is that the "animal spirit" contained in the ventricular cavity enters the tube and is conveyed by it to the various muscles with which it is connected, so as to produce the appropriate motions. The whole system, although it was placed under the supervision of the "*âme raisonable*," which had its office in the pineal gland, was capable of working independently. As instances of this mechanism Descartes gives the withdrawal of the foot on the approach of hot objects, the actions of swallowing, yawning, coughing, etc. As it is necessary that in the performance of these complicated motions, the muscles concerned should contract in succession provision is made for this in the construction of the systems of tubes which represent the motor nerves. The weakness of the scheme lies in the absence of fact basis. Neither threads nor pores nor tubes have any existence.

The same year that J. R. Mayer published his memorable essay, it was discovered by E. H. Weber that, in the vagus nerve, which springs from the medulla oblongata and proceeds therefrom to the heart, there exist channels of influence by which the medulla acts on that wonderful muscular mechanism. Almost at the same time with this, a series of discoveries* were made relating to the circulation, which, taken together, must be regarded as of equal importance with the original discovery of Harvey. First, it was found by Henle that the arterial blood-vessels by which blood is distributed to brain, nerve, muscle, gland, and other organs, are provided with muscular walls like those of the heart itself, by the contraction or dilatation of which the supply is increased or diminished according to the requirements of the particular organ. Secondly, it was discovered simultaneously, but independently, by Brown-Séquard and Augustus Waller, that these arteries are connected by nervous channels of influence with the brain and spinal cord, just as the heart is. Thirdly, it was demonstrated by Bernard that what may be called the heart-managing channels spring from a small spot of gray substance in the medulla oblongata, which we now call the "heart-center;" and a little later by Schiff, that the artery-regulating channels spring from a similar head-central office, also situated in the medulla oblongata, but higher up, and from subordinate centers in the spinal cord.

If I had the whole day at my disposal and your patience were inexhaustible, I might attempt to give an outline of the issues to which these five discoveries have led. As it is I must limit myself to a brief discussion of their relations to each other, in order that we may learn something from them as to the nature of automatic action.

Sir Isaac Newton, who, although he knew nothing about the structure of nerves, made some shrewd forecasts about their action, attributed to those which are connected with muscles an alternative function. He thought that by means of motor nerves the brain could determine either relaxation or contraction of muscles. Now, as regards ordinary muscles, we know that this is not the case. We can will only the shortening of a muscle, not its lengthening. When Brown-Séquard discovered the function of the motor nerves of the blood vessels, he assumed that the same limitation was applicable to it as to that of muscular nerves in general. It was soon found, however, that this assumption was not true in all cases—that there were certain instances in which, when the vascular nerves were interfered with, dilatation of the blood-vessels, consequent on relaxation of their muscles, took place; and that, in fact, the nervous mechanism by which the circulation is regulated is a highly-complicated one, of which the best that we can say is that it is perfectly adapted to its purpose. For while every organ is supplied with muscular arteries, and every artery with vascular nerves, the influence which these transmit is here relaxing, there constricting, according (1) to the function which the organ is called upon to discharge; and (2) the degree of its activity at the time. At the same time the whole mechanism is controlled by one and the same central office, the locality of which we can determine with exactitude by experiment on the living animal, notwithstanding that its structure affords no indication whatever of its fitness for the function it is destined to fulfill. To judge of the complicated nature of this function we need only consider that in no single organ of the body is the supply of blood required always the same. The brain is during one hour hard at work, during the next hour asleep; the muscles are at one moment in severe exercise, the next in complete repose; the liver, which before a meal is inactive, during the process of digestion is turgid with blood, and busily engaged in the chemical work which belongs to it. For all these vicissitudes the tract of gray substance which we call the *vascular center* has to provide. Like a skillful steward of the animal household, it has, so to speak, to exercise perfect and unfailing foresight, in order that the nutritive material which serves as the oil of life for the maintenance of each vital process, may not be wanting. The fact that this wonderful function is localized in a particular bit of gray substance is what is meant by the expression "automatic action of a center."

But up to this point we have looked at the subject from one side only.

No state ever existed of which the administration was exclusively executive—no government which was, if I may be excused the expression, absolutely absolute. If in the animal organism we impose on a center the responsibility of governing a particular mechanism or process, independently of direction from above, we must give that center the means of being itself influenced by what is going on in all parts of its area of government. In other words, it is essential that there should be channels of information passing inward, as that there should be channels of influence passing outward. Now, what is the nature of these channels of information? Experiment has taught us not merely with reference to the regulation of the circulation, but with reference to all other automatic mechanisms, that they are as various in their adaptation as the outgoing channels of influence. Thus the vascular center in the medulla oblongata is so cognizant of the chemical condition of the blood which flows through it, that if too much carbonic acid gas is contained in it, the center acts on information of the fact, so as to increase the velocity of the blood-stream, and so promote the arterialization of the blood. Still more strikingly is this adaptation seen in the arrangement by which the balance of pressure and resistance in the blood-vessels is regulated. The heart, that wonderful muscular machine by which the circulation is maintained, is connected with the center, as if by two telegraph wires—one of which is a channel of influence, the other of information. By the latter the engineer who has charge of that machine sends information to headquarters whenever the strain on his machine is excessive, the certain response to which is relaxation of the arteries and diminution of pressure. By the former he is enabled to adapt its rate of working to the work it has to do.

If Dr. Whytt, instead of cutting off the head of his frog, had removed only its brain—*i. e.*, the organ of thought and consciousness—he would have been more astonished than he actually was at the result; for a frog so conditioned exhibits, as regards its bodily movements, as perfect adaptiveness as a normal frog. But very little careful observation is sufficient to show the difference. Being incapable of the simplest mental acts, this true animal automation has no notion of requiring food or of seeking it, has no motive for moving from the place it happens to occupy, emits no utterance of pleasure or distress. Its life processes continue so long as material remains, and are regulated mechanically.

To understand this all that is necessary is to extend the considerations which have been suggested to us in our very cursory study of the nervous mechanism by which the working of the heart and of arteries is governed, to those of locomotion and voice. Both of these we know, on experimental evidence similar to that which enables us to localize the vascular center, to be regulated by a center of the same kind. If the behavior of the brainless frog is so natural that even the careful and intelligent observer finds it difficult to attribute it to anything less than intelligence, let us ask ourselves whether the chief reason of the difficulty does not lie in this, that the motions in question are habitually performed intelligently and consciously. Regarded as mere mechanisms, those of locomotion are no doubt more complicated than those of respiration or circulation, but the difference is one of degree, not of kind. And if the respiratory movements are so controlled and regulated by the automatic center which governs them, that they adapt themselves perfectly to the varying requirements of the organism, there is no reason why we should hesitate in attributing to the centers which preside over locomotion powers which are somewhat more extended.

But perhaps the question has already presented itself to your minds, What does all this come to? Admitting that we are able to prove (1) that in the animal body, product is always proportional to process; and (2), as I have endeavored to show you in the second part of my discourse, that Descartes' dream of animal automatism has been realized, what have we learnt thereby? Is it true that the work of the last generation is worth more than that of preceding ones?

If I only desired to convince you that during the last half-century there has been a greater accession of knowledge about the function of the living organism than during the previous one, I might arrange here in a small heap at one end of the table the physiological works of the Hunters, Spallanzani, Fontana, Thomas Young, Benjamin Brodie, Charles Bell, and others, and then proceed to cover the rest of it with the records of original research on physiological subjects since 1831. I should find that, even if I included only genuine work, I should have to heap my table up to the ceiling. But I apprehend this would not give us a true answer to our question. Although, etymologically, science and knowledge mean the same thing, their real meaning is different. By science we mean, first of all, that knowledge which enables us to sort the things known according to their true relations. On this ground we call Haller the father of physiology, because, regardless of existing theories, he brought together into a system all that was then known by observation or experiment as to the processes of the living body.

But in the "Elementa Physiologiæ" we have rather that out of which science springs than science itself. Science can hardly be said to begin until we have by experiment acquired such a knowledge of the relation between events and their antecedents, between processes and their products, that in our own sphere we are able to forecast the operations of nature, even when they lie beyond the reach of direct observation. I would accordingly claim for physiology a place in the sisterhood of the sciences, not because so large a number of new facts have been brought to light, but because she has in her measure acquired that gift of prevision which has been long enjoyed by the higher branches of natural philosophy. In illustration of this I have endeavored to show you that every step of the laborious investigations undertaken during the last thirty years as to the process of nutrition, has been inspired by the previsions of J. R. Mayer, and that what we have learnt with so much labor by experiments on animals is but the realization of conceptions which existed two hundred years ago in the mind of Descartes as to the mechanism of the nervous system. If I wanted another example I might find it in the previsions of Dr. Thomas Young as to the mechanism of the circulation, which for thirty years were utterly disregarded, until, at the epoch to which I have so often adverted, they received their full justification from the experimental investigations of Ludwig.

But perhaps it will occur to some one that if physiology founds her claim to be regarded as a science on her power of anticipating the results of her own experiments, it is unnecessary to make experiments at all. Although this objection has been frequently heard lately from certain persons who call themselves philosophers, it is not very likely to be made seriously here. The answer is, that it is contrary to experience. Although we work in the certainty that every experimental result will come out in accordance with great principles (such as the principle that every plant or animal is both, as regards form and function, the outcome of its past and present conditions, and that in every vital process the same relations obtain between expenditure and product as hold outside of the organism), these principles do little more for us than indicate the direction in which we are to proceed. The history of science teaches us that a general principle is like a ripe seed, which may remain useless and inactive for an indefinite period, until the conditions favorable to its germination come into existence. Thus the conditions for which the theory of animal automatism of Descartes had to wait two centuries, were (1) the acquirement of an adequate knowledge of the structure of the animal organism, and (2) the development of the sciences of physics and chemistry; for at no earlier moment were these sciences competent to furnish either the knowledge or the methods necessary for its experimental realization; and for a reason precisely similar Young's theory of the circulation was disregarded for thirty years.

I trust that the examples I have placed before you to-day may have been sufficient to show that the investigators who are now working with such earnestness in all parts of the world for the advance of physiology, have before them a definite and well-understood purpose, that purpose being to acquire an exact knowledge of the chemical and physical processes of animal life, and of the self-acting machinery by which they are regulated for the general good of the organism. The more singly and straightforwardly we direct our efforts to these ends, the sooner we shall attain to the still higher purpose—the effectual application of our knowledge for the increase of human happiness.

The science of physiology has already afforded her aid to the art of medicine in furnishing her with a vast store of knowledge obtained by the experimental investigation of the action of remedies and of the causes of disease. These investigations are now being carried on in all parts of the world with great diligence, so that we may confidently anticipate that during the next generation the progress of pathology will be as rapid as that of physiology has been in the past and that as time goes on the practice of medicine will gradually come more and more under the influence of scientific knowledge. That this change is already in progress we have abundant evidence. We need make no effort to hasten the process, for we may be quite sure that, as soon as science is competent to dictate, art will be ready to obey.

* The dates of the discoveries relating to this subject here referred to are as follows: Muscular Structure of Arteries, Henle, 1841; Function of Cardiac Vagus, E. H. Weber, 1845; Constricting Nerves of Arteries, Brown-Sequard, 1852, Aug. Waller, 1853; Cardiac Center, Bernard, 1858; Vascular Center, Schiff, 1858; Dilating Nerves, Schiff, 1854; Eckhard, 1864; Loven, 1866. Of the more recent researches by which the further elucidation of the mechanism by which the distribution of blood is adapted to the requirements of each organ, the most important are those of Ludwig and his pupils and of Heidenhain.

RABIES—A POSSIBLE CAUSE AND A PROBABLE PREVENTIVE.

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IT is probably owing to the great obscurity that surrounds the etiology, pathology, and treatment of rabies that it is exciting so much study. Taking these divisions of the subject up inversely, it may be remarked that experience in the treatment of this terrible disease has thus far furnished no favorable results. In this respect there has been less accomplished than in the case of any disease known to both ancient and modern times. In the few cases chronicled as cured there have invariably been good grounds to question the diagnosis; for in a perhaps purely nervous disease like this there is plenty of room for exercising the imagination both of the patient and of the physician. It is safe to say that in no case of undoubted rabies has death failed to result speedily, and that there is no known cure.

Of the pathology, we have none that is recognized by the general profession. Whether it is primarily a disease of the blood, which sooner or later affects the nervous system, or whether the effects are exerted directly on the nervous system, is not known. Both systems seem to be the theater of the disease in man. No contusion or rupture of the skin can occur but there is of course more or less of an impression on the nerves; but it seems to be necessary that the poisonous saliva shall reach the absorbents to produce the effects, and then it is a comparatively few who are bitten by a really rabid animal who take the disease. Injury of the peripheral nerves, when there is no possibility of the wound being poisoned, may produce tetanus, a disease much resembling rabies. A comparison of these two diseases shows that the history is similar, the symptoms being markedly alike in many respects, and the results of treatment in most instances not much different, for Dr. O'Beirne, of Dublin, witnessed two hundred cases of tetanus without a single recovery. It may be that rabies is a form of tetanus, but that the special poison has a particular affinity for the nerves governing the muscles connected with the acts of deglutition and respiration. There are poisons that produce analogous peculiar and special effects. Dr. A. Flint, Jr., says: "Woorara, a poison, has the remarkable property of paralyzing the motor nerves; but leaving the nerves of sensation intact." This drug has been used in the treatment of both tetanus and rabies for these reasons, but with no marked results. Cantharis has a special effect on the mucous membranes of most persons, and it may kill if the dose is sufficiently large. There are many drugs, of vegetable and mineral origin, that have special effects on certain organs.

The symptoms of rabies are well known and generally unmistakable to an unprejudiced mind; but until we more fully understand the causes we cannot expect to prevent this malady. The same may be said of the pathology; for until we understand the pathology, especially during its incubation, we cannot expect to treat the complaint intelligently or successfully. But little has been said of the etiology in all that has been published of late on this subject, and when the pathology and treatment have reached a non-progressive stage, it is time—not to abandon them—but to direct the attention of thinking people to the cause, that steps may be taken for prevention; and there is something to be said on this point. We are not satisfied to sit down and say, "What cannot be cured must be endured;" for what cannot be cured in medicine must be prevented, says modern science. In recent medicine it is possible that the prevention of disease has done more to prolong human life than therapeutics, whether based on pathology or not. It may be that such will be the case with rabies; and that in the absence of any cure, and with certain death in prospect, the grain of prevention may be of great value. As instances where progress has been made by adopting this line of defense, it is only necessary to mention the management today of yellow fever, cholera, small pox, etc. For these infectio-contagious diseases there are no cures, but we see how much can be accomplished by prevention; which in fact is almost total annihilation. How can these arguments be applied to rabies?

The Possible Cause.—In a study of the natural history of the dog we find that he is an animal existing in nearly every country of the world, both in the wild and in the domesticated condition. He is indigenous to nearly all lands. The theory that the dog is a descendant from the wolf is not tenable.

Rabies has been known among dogs as far back as history speaks of them. It is also found that it has prevailed most in the most thickly-settled countries, and those having the most intimate and constant communication with other nations; and from those peoples it can be traced just in proportion as they made discoveries and conquests of other lands; for wherever civilized man has gone he has taken dogs, and in those lands rabies has then appeared, and not until then.

In the Mauritius Islands it was not known until 1821, when it appeared soon after a dog arrived there on an English ship from Bengal. It is not mentioned whether this dog was allowed intercourse with the native dogs, thereby giving opportunity for generating or spreading the disease by contagion, but it is presumed the greatest liberty existed.

In Labrador, Liberia, Australia, Van Diemen's Land, and New Zealand, places in but comparatively slight communication with the rest of the world, rabies is seldom if ever heard of. In relation to Greenland, heretofore reckoned in the list, Professor Agnew says, in his recent "Surgery:" "In 1863 it prevailed to such an extent in Northern Greenland as to destroy all the dogs in certain localities." It must be remembered that communication with Greenland is getting more and more frequent, and that the Esquimau dog is said to be fast crossing with the wolf. Erichsen says: "Rabies is not known in Central Africa in any animals."

As regards China and Japan, countries notably exclusive of both men and animals from foreign lands, and where they have mostly one breed of dogs, rabies is seldom heard of. Authorities differ, however, in this respect. Dr. H. W. Boone, surgeon in charge of St. John's College, Shanghai, China, writing under date of June 28, 1881, says: "The ordinary Chinese dog is large, sort of half-wolf, like Indian or Esquimau dogs, but they have small Pekin pugs and small Canton dogs. Chinese dogs occasionally cross with European dogs, but only at the few open ports. The pure Chinese dogs have hydrophobia, and did so in early days

before foreign contact was common. Japan the same." Dr. D. B. Simmons, for many years a resident in Yokohama, Japan, writing under date of March 10, 1881, says: "I have never seen an unmistakable case of rabies in a Japanese. I saw one case in a foreign child who was bitten by a foreign dog, a Newfoundland. The dogs here are large wolf-like beasts, having their origin no doubt in China."

Without doubt dogs have been taken to all of these places, and perhaps allowed to live there for years, but they were probably dogs of a pure and original breed, and were not permitted to accompany or cohabit with the native dogs. And here hangs the point of my argument as regards the cause of rabies—that is, that a dog of a pure and original breed is incapable of generating rabies, and that it never appears in any land until such dogs breed in-and-in with dogs of other countries, producing the mixed or mongrel dog. All dogs receive and give the contagion, but only the mongrel can *generate it*. Such seems to be the proper deduction to make from the history of rabies, and such is the conclusion that observers of dogs and of this disease are fast approaching. Charles Hamilton Smith says that "the Newfoundland dog is an original breed, and true hydrophobia does not attack them in their native land." The same author, in speaking of Arctic dogs, says: "Arctic dogs in their native regions, are not liable to canine madness." He also says: "Of all domestic dogs, the greyhound is the least liable to hydrophobia." It is also true that the greyhound is the least apt to breed with other dogs; they are peaceable, keep mainly by themselves, and are no doubt of a pure and original breed. Erichsen says: "Among dogs, rabies is the most common in those of mongrel breed, seldom affecting those of pure blood." John W. Hill, R. C. V. S., in speaking of the causes, says: "I am very much inclined to think breeding in-and-in encourages its development." Dr. Verity, in the Manchester *Courier* of 1876, says: "I have always had a strong opinion that breeding in-and-in tends to produce hydrophobia in the dog." There are many instances in human beings where crossing the race tends to produce men inferior in intellectual force and physical bearing, with a strong tendency to disease. If we want a perfect specimen of the intellectual and physical make of any race we find it among those of pure and unadulterated blood. The crossing of nations of the same race produces, undoubtedly, a superior class of men, but the crossing of different races only produces inferiors, natural criminals, and idiots. There are a few exceptions, but they only make the rule more apparent and forcible. The Caucasian and Indian crossing we all know the result of—weak, criminal, and sickly offspring. There are no King Philips or Sitting Bulls who are half-breeds. The results of the crossing of the negro and white man are numerous among us, and generally they are objects of pity, and die early. The few with us of the cross of Chinese and Caucasian are the despised of both nations. The Mexicans are largely a cross between the Spaniard and the native Indian, and are a weak, degenerating, dying people, far lower in intelligence and physique than the Spaniard of Spain or the historical Aztec. To return to the brute creation, it is only necessary to say that the breed is not improved by crossing the common horse with the Arabian or Shetland. Cattle are not improved by crossing with the buffalo. These instances all seem to admonish us to keep the breeds, whether of human beings or of animals, pure and of the original race. It may be that rabies is the result of the violation of this seeming law of nature; and, if so, the prevention would be easy—that is, to allow none but dogs of a pure and original breed to live. How easy this would be to try in a land like England, where laws are made to be enforced; and it would not be hard to determine which were of a pure breed. It is possible, in my belief, that, if dogs of different breed were prevented from crossing or their progeny disposed of, rabies might be prevented. In the absence of a cure, the trial of this measure may be deemed advisable.

The question naturally arises, Which are the dogs of a pure breed? We have to regret that nothing is *positively* known on this point, history being incomplete. Recent authorities, such as Charles H. Smith, Thomas Bell, and Youatt, speak in no decided words on this point, using the indefinite terms probably, evidently, etc.; but the following-named are with little doubt directly descended from the wild dog: the shepherd dog, the mastiff, the greyhound, the hound, the spaniel, the Newfoundland, the Esquimau, the terrier, and the cur. The shepherd has been considered the primitive dog. He is no doubt the original dog of Western Asia and Egypt. The mastiff may be indigenous to England or the higher lands of Asia and Africa. The greyhound is very ancient, having been known three thousand years ago, when it differed in no important particular from that of the present day. The British Museum contains a group of greyhound puppies in stone, from the ruins of the villa of Antonius. The greyhound was an inmate of Anglo-Saxon kennels in the time of King Elfric. The hound and spaniel are natives of Spain. The Newfoundland is indigenous to that island, and was not known in Europe until imported from there. The Esquimau dog is a native of the more northern latitudes, and is more like the wolf than any other species, yet is reckoned as the native dog. The majority of those seen at the present time may be a cross with the wolf. The terrier is considered indigenous to Great Britain. Curs are the most numerous, and are the native dogs of many countries; but, having no well-marked characteristics, they have received no definite name, and are often confounded with the mongrel dogs. There may be others, but these are the principal ones.

The Probable Prevention.—It has been very generally admitted that climate makes no difference with the appearance of the disease. Professor G. Canettoli, in *Lo Sperimentale* for June, 1875, says, in writing of rabies: "This is a disease of all climates; the extremes have the smallest number." Mr. Hill says: "The influence of climate, season, or sex would appear to have little bearing on the subject." This conclusion is from a European standpoint.

The Pacific coast of America presents some peculiar features as regards this disease. We have in this city, and in a portion of the State, a peculiar climate, which cannot be compared with that of any other portion of the world. But we have also in this large State, and on the Pacific coast, thickly-settled towns and cities where the extremes of heat and cold are well marked and can be brought into comparison with those of places in the Eastern States and Europe; yet, from Behring's Strait to Cape Horn, not a well authenticated case of rabies was ever known. Dr. Logan, recently United States Minister to Chili, in a little work published in Chicago, called "Physics of the Infectious Diseases," says: "Of the remarkable disease called hydrophobia, the author believes himself justified in saying that it has never been known upon the whole coast." Dr. F. C. Valentine, of Guatemala, writes, under a recent date, and after eleven years' residence in Central America: "I have not encountered one authenticated case of rabies during my residence here." Dr. G. Chismore, of San Francisco, a gentleman fond of dogs, and who lived several years in Alaska, says, under date of June 11, 1881: "I never saw or heard of a case of rabies among Alaskan dogs." Dr. F. W. Hatch, permanent Secretary of the State Board of Health of California, in a note dated February 20, 1879, says: "There are no cases of, or deaths from, hydrophobia on the records of the State Board of Health. Personally I know of no cases of the disease in the State." The records of the Health Office in San Francisco furnish no evidence that there has ever been a death from rabies in the city. Is it truthfully stated, then, that climate has no influence over this disease?

It seems to be well proven that rabies prevails more or less in nearly all portions of the world that have been long in communication with the older nations, but that it does not prevail on the American Pacific coast in any animals, brute or human, while at the same time there is every kind of climate from the north frigid, through the temperate and tropic, to temperate and frigid again. Whatever the future may bring, the past gives no record or knowledge of the existence of rabies. Why we are so wonderfully and fortunately favored cannot, perhaps, be positively made out.

It is reasonable to suppose that among the many human beings and animals who are bitten every year by really rabid dogs in the Eastern States and in Europe, some one or more, considering the possibly long period of incubation, must have reached the Pacific coast; yet not one case has been developed, while dogs are numerous and of great variety, from the pure-blooded greyhound to the scurvy mongrel.

Dr. Verity, in an article on this subject which appeared in the Manchester *Courier* of 1876, approaches what may be considered some explanation. He says: "Certain peculiar changes in the system, possibly due to atmospherical influences, act in producing it." If this be true, may not other atmospherical influences act to restrain or annihilate the poison? We have a recognized condition of the atmosphere on the coast, called electrical; and all are aware of the wonderful effects of artificially generated electricity when used in the treatment of nervous and other diseases. A test of the power of the climate of the American Pacific coast to prevent the development of rabies can easily be made, with strong probability of proving a blessing to hundreds of human beings who have no other hope. The period of incubation is so long in many cases that several dogs known to be badly bitten by a dog known to be suffering with rabies could be sent here under guard and kept behind prison bars and under observation until the extreme limit was passed. Or a more practicable plan might be to have a number of the many persons who are annually bitten by rabid dogs in the Eastern States and Europe come to this coast, and remain here until the extreme limit of the possibilities was passed, selecting any place from Cape Horn to Behring's Strait, preferably, however, California, where we have a varied climate and all kinds of dogs, and are in close communication with all parts of the world. The patient having a knowledge of these facts, and the support of hope of escape, it might be a power to prevent an attack; and, if he were attacked, the disease might be so modified by the climate as to render it susceptible of cure.—*New York Medical Journal.*

HEAVY PARAFFIN OIL IN PHARMACY.

By CHARLES SYMES, Ph.D.

THIS was a paper read at a recent meeting of the British Pharmaceutical Conference.

Crude petroleum and rock oils contain a number of bodies of scientific interest, but when distilled commercially they yield benzoline or petroleum spirit, burning oils of various densities, heavy or lubricating oil, a soft uncrystallizable fatty substance, which, when highly purified, is known as vaseline, petroleum jelly, cosmoline, unguentum petrolei, etc., and paraffin wax of various degrees of hardness, and melting at various temperatures, from 100° F. to 128° F.

These products are saturated hydrocarbons, characterized by their chemical indifference to other substances. The body to which I wish specially and briefly to direct attention is the heavy oil, which, although used extensively for lubricating purposes, has not, as far as I am aware, found its way into pharmacy, except in combination with paraffin wax, as a solid, more or less crystalline, substance. The best oil, as usually found in the market, is of the color and specific gravity of olive oil (0·910), possesses a boiling point above 480° F., and but little odor. It is optically active, rotating the polarized ray —3·50°. It sometimes has a slightly acid reaction, probably due to the treatment it has previously undergone in its purification. These latter objectionable qualities can be removed by passing it through ordinary granulated animal charcoal, and it is then in a suitable condition for such pharmaceutical purposes as it is adapted. It has, even when thus further purified, some amount of fluorescence (commonly known as bloom), which has been regarded as objectionable; the oil imported from Russia has very little of this, and in the sample I have here (somewhat paler and thinner than the other) it is entirely absent. It is by no means certain, however, that a ready method of destroying this characteristic is desirable, inasmuch as it would render it capable of being used for purposes of adulteration, from which, happily, it is now precluded on account of its easy detection.

Heavy paraffin oil is in itself an excellent emollient when applied to the skin; but, in addition to this, I feel satisfied it might be used with advantage as a vehicle for many more active remedies. It dissolves half its weight of camphor, thus forming a strong camphorated oil, which keeps good indefinitely. Mixed with one-twentieth of its weight of carbolic acid, we have an excellent antiseptic dressing for wounds; it also dissolves thymol and menthol when gently warmed. Simple ointment, in which the almond oil is replaced by this oil, is an excellent basis for other ointments, as it does not readily become rancid, the paraffin oil not only resisting oxidation itself, but acting as a preservative of the lard present. In this latter remark I have been anticipated to some extent by Mr. J. B. Moore, of Philadelphia, who published an elaborate paper in the July number of the New York *Druggists Circular*, "On a New Basis for Ointments and Substitute for Lard." His proportions were somewhat different from mine, and he used cosmoline, not paraffin oil; but the general results were the same, and his experiments were conducted through a long period, and under trying circumstances as to temperature.

The ointment, of which I have here a sample, is of a pale yellow color, is about the same consistence as ordinary simple ointment, free from odor, and keeps good for a long period.

These are only a few of the useful purposes to which, in my opinion, heavy paraffin oil might be applied in pharmacy.

A vote of thanks having been passed to the author,

Professor Armstrong said one very remarkable statement was made, namely, that this paraffin oil was dextrorotary. He should like to know the length of the tube used.

Mr. Symes said it was a 100 mm. tube.

Professor Thorpe said this was the first example of any product got by destructive distillation having such optical properties.

Mr. Benger asked if there was not a little practical difficulty in the use of mineral fats as substitutes for animal fats, namely, the difficulty with which they were removed from linen or the skin by means of soap.

Mr. Allen said it was entirely new to him that the petroleum products had any rotary action on polarized light; at the same time he would remind Professor Thorpe that rosin oil, which was a product of destructive distillation, was not unfrequently optically active.

Dr. Tilden said it occurred to him that a trace of turpentine might have got into the particular specimen which Mr. Symes examined, which might produce the effect referred to.

Mr. Allen said with respect to fluorescence he might say that one of the processes by which these oils, or at any rate shale oils, which were very similar, might be deprived of fluorescence was by treating them with nitric acid, or certain other oxidizing agents in a very limited manner. It was possible in many cases where they had been artificially "debloomed," so to speak, to restore them so as to indicate the origin of the oil by mixing it with sulphuric acid, in which case the bloom or fluorescence reappeared. However, there came from America a heavy lubricating oil, naturally free from bloom, and in which no bloom could be developed by treatment with acid. Respecting their mixture with other oils it was an interesting fact that these petroleum products did not mix with castor oil. Castor oil dissolved about an equal measure, but any further quantity did not mix with the petroleum oil; it was an extraordinary thing that castor oil should constitute an exception to the other fatty oils which they were in the habit of thinking were so easily miscible with these hydrocarbons.

Mr. Gerrard said on the pharmaceutical side of the question, he had made a considerable number of experiments in a similar direction to those of Mr. Symes. The ordinary commercial lubricating oils were not at all adapted for medicinal use and application. They were subject to considerable variation, as might be easily demonstrated by the application of a little strong sulphuric acid to any of the commercial lubricating oils; most of them became blackened to a high degree. He had devised a process for the purification of these oils, which had been used to some extent at the University College Hospital, and also largely during the epidemic of small-pox at a hospital in North London. The method adopted was to treat the ordinary lubricating oil first with strong sulphuric acid, which produced a considerable charring, and then to allow it to stand for some time, when a clear oil separated, which was removed, and it was well washed with caustic soda or ammonia; then the clear oil was removed again, and well washed with water until it gave a neutral reaction. This purified oil, when treated with about one-sixth of its weight of paraffin wax, formed an ointment basis exactly similar in composition and physical properties to the substances now being sold to imitate vaseline. They all possessed a crystalline structure which must be considered to be a disadvantage when compared with vaseline.

Mr. A. C. Abraham said that these lubricating petroleum oils were very often adulterated, with the intention of improving them, with fatty oils, and that might possibly account for the results obtained, to some extent.

Mr. Fletcher asked if Mr. Symes had found that the agitation, with acid of petroleum having a bloom or fluorescence, destroyed that fluorescence, as Mr. Allen had stated; and if so, what acid produced that effect. It was a fact, well known to every pharmacist, that the fluorescence of quinine was entirely destroyed by a mere trace of hydrochloric acid, and it would be interesting to know whether the same thing occurred with paraffin.

Mr. Conroy said his experience was that with the better qualities of heavy mineral oil about one-third was dissolved by castor oil, but very singular to say the portion dissolved by the castor oil contained the principal portion of the coloring matter of the mineral oil. He had worked in that direction for a short time with the hope that he would be able to decolorize mineral oil with castor oil; but he had not been successful. Although he was able to remove the greater portion of the coloring matter, still there was too much of the mineral oil dissolved away with it. In reference to what Mr. Gerrard had said relative to the articles in the market of the nature of vaseline, he must emphatically, in connection with one of them, contradict the statement that it was made with paraffin wax.

Mr. Symes, in reply to Dr. Tilden, said he took a good commercial specimen, and, therefore, he probably had not sufficiently assured himself of the absence of possible impurities. But when one spoke of destructive distillation he should rather regard the process of obtaining these things as one of fractional distillation; he was not sure the temperature used was sufficient to be regarded as destructive distillation, but merely as a separation of the constituents already existing in the crude substances. With regard to the difficulty of removing it from linen, he had only to call attention to the fact that there was such a thing as vaseline soap, and if there was any vaseline in it he supposed it possessed cleansing detergent properties. The treatment Mr. Gerrard referred to, alternately with acids and alkalies, was the one he referred to as possibly helping to cause the acid reaction; but the oil was always subjected to that process in purification to get rid of olefines and some other impurities. He feared if any one attempted to make artificial vaseline with paraffin wax of low melting point to the proportion of 1 to 7 it would be nearly all oil in summer weather. It required from 20 to 25 per cent. of low melting point paraffin. From some experiments made in that direction he found the higher the melting point of the paraffin used the more crystalline would be the product and the less percentage of paraffin would be required, while the lower the melting point of the paraffin the more would be required and the less crystalline and better the product and the nearer it was to the substance known as vaseline. But he took it all these substances, vaseline and such like, had never been in the crystalline condition. They were the soft fatty substances of which he spoke, which in an impure state were used for lubricating. It was this fact which gave it the particular jelly like look so different to most of the artificially produced bodies.

AFFINITY AND VALENCY.

By FRED. D. BROWN.

THOSE chemists who were present at the recent meeting of the British Association must have been struck with the unanimity which prevailed in the Chemical Section with regard to that important property of the elements which we term valency or atomicity. Professors Williamson, Odling, Roscoe, and others, successively declared that it was impossible to attribute a constant combining power to the atoms, while it was more than once argued that if the idea of valency be retained in the science at all, it must be understood to refer to a property of the atoms which is subject to variations of unlimited extent.

This question has much occupied my attention during the present year, and I have gradually come to the conclusion that the force of affinity with which an atom tends to combine with another is unaltered, or but little altered, by such combination; in other words, if a force of attraction, F, be exerted between two atoms, A and B, this force will remain the same whether A be combined with one or more atoms, C, D, etc., whether it be combined with a second atom, A, or whether it lead for the time being an independent existence.

Many arguments in support of this hypothesis have from time to time occurred to me. Some of these are contained in a paper published in the October number of the *Philosophical Magazine*, but none, in my opinion, is more cogent than that derived from the very existence of chemical reactions. It is frequently said that the atoms forming the molecules of most chemical substances "have their affinities satisfied," and it is, I think, generally supposed that the chemical energy or affinity of the atoms is neutralized, such neutralization being regarded as in some respects similar to that which takes place when a conductor charged with positive electricity is brought into contact with another which has received a negative charge. Yet, on reflection, it is evident that if this were the case it would not be possible for the molecule in question to exert any influence upon another, or, *a fortiori*, to enter into any chemical reaction. This argument will be better understood by applying it to some simple reaction, such, for example, as the formation of hydrochloric acid from hydrogen and chlorine, which we are accustomed to express by the equation—

$$H_2+Cl_2=2HCl.$$

The molecule, H_2, is supposed to be made up of two atoms of hydrogen united together by the force of chemical affinity in precisely the same manner as an atom of hydrogen is joined to an atom of chlorine in hydrochloric acid. Now, if neutralization takes place at all between these two atoms it must be complete, for they are identical, and therefore neither of them can have a surplus of the attractive force available after the rest has been employed in neutralizing that of the other; but if the neutralization be complete, neither atom is in a position to combine with an atom of chlorine or to attract it in any way; hence the reaction cannot take place as long as the atoms of hydrogen are united together. That they remain thus united when left alone is proved by the fact that hydrogen gas obeys Avogadro's law. Since the reaction does take place we are bound to assume that in the molecule, H_2, the affinity of the hydrogen atoms is not neutralized.

If we are forced to this conclusion in this particular case of hydrogen, we are equally so in the case of most other elements, but with compound bodies the argument is more complicated. Take, for instance, the case of water. We wish to show that the atoms of hydrogen and oxygen which form its molecule retain their original attractive forces when they are thus combined together. Now we can imagine (1) that the attractive forces are entirely neutralized; (2) that the hydrogen is only sufficient to neutralize a part of the affinity of the oxygen, leaving the rest free to act upon any other atom; (3) that the oxygen is only sufficient to neutralize a part of the affinity of the hydrogen atoms, leaving the rest free to act upon other atoms; (4) that the affinities are not neutralized at all.

We have already seen that the first supposition is inadmissible, since the molecule of water reacts upon other molecules. As regards the second view, that the attractive force of the hydrogen alone is entirely neutralized, it is discountenanced by the fact that chlorine acts upon the hydrogen of water, forming hydrochloric acid, and setting free the oxygen. It is true that this reaction is not one of everyday occurrence, but there is no doubt that under suitable conditions it really takes place. The third hypothesis, that the attraction of the oxygen is entirely neutralized, is disproved by numberless reactions in which the oxygen is attacked by atoms belonging to other molecules, while the hydrogen is liberated. We are, therefore, in this case also driven to the only other possible supposition, viz., that no neutralization takes place.

It would not be difficult to apply the same line of reasoning to most other compound bodies, and thus to show that *in any molecule every atom retains the same affinity or power of attraction which it possesses when it is uncombined with any other.*

If this statement be true, it follows that, as far as the force of affinity is concerned, an atom may combine with any number of other atoms, or, in other words, that its valency must be unlimited. The number of atoms which can remain sufficiently close to it to be retained within the sphere of attraction is, however, necessarily very limited. Thus we may imagine an atom of nitrogen surrounded by a considerable number of atoms of hydrogen, each of which is moving with great velocity, and some few of these may come so close to the nitrogen as to be unable to get away again; but as soon as these hydrogen atoms, which remain constantly vibrating in the immediate neighborhood of the nitrogen atom, have reached a certain number, it will become impossible for any others to approach sufficiently near to be retained permanently. We may, therefore, reasonably ascribe the phenomena of valency to the conditions of space and motion under which the atoms are placed. By so doing, and admitting that the attractive forces exerted by the atoms remain unaltered, we are enabled to overcome most of the difficulties connected with the subject, and to account to ourselves in a fairly satisfactory manner for the variation of combining power and the existence of molecular compounds. Thus, with respect to the first point, it is clear that the valency of an atom must be dependent not only on the form, size, motion, etc., of the atom itself, but also on the same attributes of the atoms which tend to combine with it. The valency, therefore, might be expected to differ with the nature of these latter bodies.

With regard to substances such as NH_4Cl, H_2SiF_6, $BaCl_2+2H_2O$, which many are accustomed to regard as molecular compounds, the hypothesis that the affinity of the atoms is undiminished by combination renders it impossible to draw any distinction between them and the so-called atomic compounds of chemistry.—*Chem. News.*

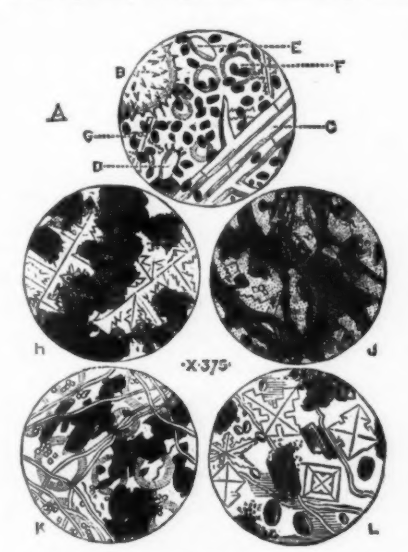
CATSUP UNDER THE MICROSCOPE.

CATSUP, as made by farmers' wives and daughters and servants, differs in a marked degree from the same condiment as sold in the shops when the different sorts are compared with each other under the microscope. Mushrooms are confessedly somewhat difficult things to understand; but if a mushroom is mystery, catsup, as sold by dealers, is a sphingian enigma that may long await a mycologic Œdipus. Housewives usually make catsup of pasture mushrooms with an addition of salt, sometimes with a little ginger, cloves, allspice, or may be, mace. This material, after being well boiled and securely corked and sealed, is one of the most delicious sauces it is possible to put upon the table. The writer of these lines being a sort of fungus fancier is of course seldom without genuine catsup in his house. "Who loves a mushroom loves good catsup, too," as the poet once wrote.

Pure, *bona fide*, home-made catsup is illustrated at A, Figure; it swarms with purple-brown mushroom spores, as shown. Occasionally a grain or two of pollen may be seen, as at B, or perhaps part of the hairlike pappus of a dandelion, as at C. A glance at the size of these minute objects by the side of the spores shows how small indeed are the spores themselves. At D is a basidium, or spore-bearer, with its four little spikes for carrying four spores; at E, a cystidium, one of the organisms referred to in a recent number (see p. 369, September 17, 1881); boiling does not destroy either of these cells or the spores but the ordinary cells of the fungus are very much broken up and obliterated in the manufacture of catsup. The circular markings at F represent drops of oil from the spices, while G shows the crystals belonging to the salt. Everything is right and proper, recognizable at a glance, and with no extraneous matter of an offensive character present.

The compound sold by dealers is sometimes termed mushroom catsup, mushroom flavor, or mushroom relish.

The four illustrations at H, J, K, and L, are camera lucida reproductions of the catsup manufactured by four different London traders. H seems to be all salt and smashed up toast; J looks like salt, decayed fish, or slime, a little mildew, and broken-up twigs; K is chiefly fungus spawn, spores of mildew, oil, crushed walnut husks, and vibriones. At L is the most respectable sample; here we have crystals of common salt, and possibly some other crystals, toast, walnut husks, and fungus spores. The manufacturer of it is a conscientious trader, for the little transparent ovals seen in the engraving belong to the brownish spores of the



CATSUP UNDER THE MICROSCOPE.

horse mushroom, and the large dark ones to one of the deliquescent species of coprinus, such as one sees growing to perfection in wet, foggy weather, about rotten palings. Costermongers and their families gather these things in the suburbs of London, and the fungi never fail to produce an abundance of rich, black juice, suitable as a substitute for permanent black writing ink.

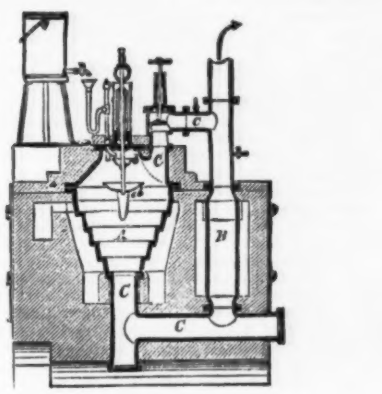
One might well feel a little mystified at the nature of shop catsup as seen under the microscope, but on turning to Cassell's "Dictionary of Cookery" one finds that catsup may be made in various ways and of various substances. For instance, there is "fish catsup," made from the "meat from a lobster;" "lobster catsup," undescribed; "anchovy catsup," made from "half a gallon of mild ale" and "two dozen pickled anchovies;" "cucumber catsup," made (not from *Agaricus cucumis*, but) by sprinkling salt over mashed cucumbers; "mussel catsup," made by pounding mussels in a mortar and boiling in wine or cider; mustapha catsup, made from a "sound ox-liver" (not the valuable "vegetable liver"—a rich entertainment for a refined diner—common on rotten oaks); pudding catsup, undescribed. Besides these there are many others, as pontac catsup, undescribed; and the catsup of elderberries, "Irish walnuts" (!), lemon, oysters (not the delicious "vegetable oyster"—*Agaricus ostreatus*—a treat for an epicure—common on rotten elms), tomatoes, walnuts, and "seven years" (!), unfortunately undescribed.

It is clear we must not be too hard on the dealers or always expect to see spores in catsup. While looking for paltry mushroom spores we may be overlooking a choice preparation of mustapha, pontac, pudding, or the rare "Irish walnuts," to say nothing of ox-liver, pounded mussels, oysters, or "meat of a lobster." Dr. Bull once made some unequaled catsup, without boiling; the thrill on the palate was extraordinary, and every one praised it as the perfection of catsup. On putting it under the microscope in a search for the source of the electric thrill, the sauce was found to be full of lively gyrating infusoria. Bacteria were present in millions; no one caught splenic fever, but then it must be remembered fungologists are, as a rule, proof against bacteria.

We happily do not always know what we eat and drink, and if in future the readers of the *Gardeners' Chronicle* cannot taste mushrooms in their catsup (bought at the shops) they may depend upon it they have got pontac, mustapha, or one of the others.—*W. G. Smith, in Gardeners' Chronicle.*

IMPROVED RETORT FOR OIL GAS.

IN the annexed cut a new retort for oil gas, invented by R. Drescher, of Chemnitz, Germany, is shown. The two retorts, A and B, are connected by the tubes, C C. The vertical revolving shaft has two pans or dishes at its lower end, containing the oil which is distributed on the terraced sides of the retort, A, and is converted into gases. The light



IMPROVED RETORT FOR OIL GAS.

gases rise and are carried off through the upper pipe, C. The heavy gases and vapors pass through the lower pipe, C, and from there into the retort, B, which is heated to a much higher degree than the retort, A. Here these heavy vapors are converted into a light gas, which is conducted to the coolers and scrubbers and to the gas tank.

FERROUS-OXALO-CITRATE DEVELOPER.

By CAPTAIN W. DE W. ABNEY, R.E., F.R.S.

SINCE I wrote two months ago regarding this developer, experiments have been made in my laboratory with it, and to my mind the results are remarkably satisfactory. I would first, however, detail some experiments made by Mr. Ray Woods for me, since they throw some light upon what might otherwise appear as discrepancies when others tried to work the developer. It may be recollected that the mode I took to make this developer was by taking potassium citrate solution, and dissolving in it as much ferrous oxalate as it would take up. At my request Mr. Woods tested the solubility of the potassium citrate in water, and the ferrous oxalate in different strengths of the citrate solution. It was found that 800 grains of potassium citrate would dissolve in one ounce of water, increasing the volume about 30 per cent. When ferrous oxalate is added to this, very little is dissolved, but a whitish powder settles, which is completely soluble in water, giving a greenish-brown solution. The powder contains oxalic acid, citric acid, potassium, and iron, the latter, curiously enough, being in both the ferrous and ferric state. The solution of this powder acts as a feeble developer. When the 400 grains of the citrate are dissolved in one ounce of water, we have a similar result. A more reasonable quantity to dissolve is 100 grains in the ounce of water, and when cold this will hardly dissolve any ferrous oxalate, but when warmed it takes up about twenty-five grains, and forms a reddish brown solution, turning greenish-brown; when in the former state it is a more vigorous developer then in the latter. If the citrate be increased to 150 grains, there does not seem to be any resulting benefit in the development. I would, therefore, propose to form the developer as below:

Potassium citrate	100 grains
Water	1 ounce
Ferrous oxalate	25 grains

The potassium salt to be dissolved first, and then the iron to be dissolved by gentle heating. By diminishing the citrate to 50 grains, and the iron to about 20 grains, the developer will be nearly as powerful.

I have already stated that this developer is an excellent substitute for the ferrous citrate developer proposed by Dr. Eder and Captain Pizzighelli for gelatine chloride plates. It is also excellent for collodion emulsion plates, since it can be employed without the use of any restrainer beyond that of the film itself. Now, to my mind, this is a most important property, as I have already stated in these columns. No one who has worked the latter process can be but aware of the danger there is of destroying the power of developing detail when such a restrainer as bromide is used. Now, in the case of this developer (always supposing it to remain in the ferrous state) there will be no destroying action; it will act simply where light has acted, and in no other parts. This, then, should be a standard developer, very much in the same way that hydrokinone is, the one variable being entirely eliminated. With gelatine-bromide plates, the development takes place with fair rapidity, and gives a beautiful image, as I have myself found in all the plates I have tried with it. The same sensitometer number is shown in trying this developer against the ferrous oxalate. The exact chemical composition of the developer is somewhat difficult to determine, but I hope to do so shortly, as it is an interesting point.

Meanwhile I may say that photographers who are using gelatine chloride according to Dr. Eder's direction will not do amiss to give this developer a trial. In this case it can be used without any restraining chloride. It is more easily prepared than that recommended by Dr. Eder, and is certainly more powerful in its action, and also more economical, which is a consideration. In regard to price, it compares favorably with the ferrous oxalate, and a great advantage over it is that the solution remains clear and free from crystallization during a lowering of temperature.

Those who still use either bath dry plates or collodion emulsion plates, will find it an invaluable aid in developing. A bath dry plate, for instance, can be developed without any of the old developing solutions, an image full of detail being brought out with a minimum exposure, the density depending on the amount of silver bromide in the film. Density, of course, can be given in the usual manner by pyrogallic acid and silver nitrate, or by acidified ferrous sulphate and silver nitrate.—*Photo. News.*

NOTES ON THE MIGRATIONS OF BIRDS.

By H. D. MINOT.

LITCHFIELD is in the highland of Western Connecticut, from nine hundred to twelve hundred feet above the sea, somewhat sparsely wooded, though well watered by southerly streams, running either into the Naugatuck valley or into the system of Bantam lake (the largest body of fresh water in Connecticut, with an area of about twelve hundred acres). My observations there extended from October, 1880, to May, 1881, inclusive of both months, and suggested to me, concerning:*

(1) *Pioneer migrants;* that the single temporary forerunners of a species, so often observed among early non-gregarious migrants before the arrival of their fellows in numbers, may serve more than a purely individual purpose. A single record will illustrate: April 1st I observed by a particular bridge the first pewee, dejected, silent, or petulant, and burried, soon flying out of sight *southward;* for a week no pewees were to be seen or heard there or anywhere about; April 8th was pewee-day, bringing these birds in numbers, and at the bridge appeared a triumphant pewee with his mate.

(2) *Local differences of time.*—Migrant cat-birds appeared in outlying swamps a week or more before the resident cat-birds returned to their village home; and king-birds appeared down by the lake, three miles off, several days before advancing to the outskirts of the much higher village. *The most favorable haunts are the first revisited.* Local differences of season, too, are very considerable: April 30, a visit to Bethlehem, nine miles southward, showed a week's advance.

(3) *The great influence of season and the comparatively little influence of temporary weather* (except on water fowl).

Crows moving southward in large bodies in the latter part of October predicted to me a severe winter. It proved one of extraordinary and almost uninterrupted severity, without any midwinter thaw. In the first week of March these crows return (three hundred debating one afternoon whether to roost in Litchfield woods or to pass on), our first spring weather forthwith followed, and real winter did not reappear. Snow-birds (*Junco hyemalis*) were absent all winter, following southward the unusually extended and steady line of frost and snow; and nuthatches and most of their kindred were absent during the latter or stormy part, marked especially by ice storms. On the other hand, some warblers, after a month of bright, lovely weather, waited to appear in the face of the cold, blustering, lasting northeaster that set in May 16. In spring, moonlight is taken advantage of by birds like water-fowl, that make long voyages in long flights; but it affects little our insessorial birds, who, however much they may profit by the harvest moon in autumn, in spring are more strongly impelled to migrate, and reappear pretty regularly, independently of the lunar calendar. For instance, at home I have noted the arrival of a particular pair of Wilson's thrushes year after year, between the 5th and the 10th of May, often coming apparently in the night, however young or old the moon might be. No doubt, however, as I have even detected sometimes, migrants that seem to have come in the night, often arrive in the evening, simply traveling till a late hour of the day before resting, and the next morning may linger for refreshment before resuming their journey. In building, on the contrary, activity is in the morning.

(4) *The uncertain order of species.*—In spite of pretty regular habits of migration among the later comers, accidental circumstances produce such variations that there is no certain order or procedure among the different kinds, even near relations. Whether the chipping or the field sparrow (Spizellas) will appear first in a given locality where both are common, who can safely predict?

(5) *The routes of New England migrants.*—In visiting Lenox, Berkshire county, Massachusetts, several years in April, I have been astonished to find that though so high (1,200–1,300 feet above the sea), and in spring so bleak and backward, it gets some of its birds (for instance, bay-winged and chipping sparrows) before either Boston on the coast or Litchfield, lower and over forty miles more south—as I have determined by returning to these places from Lenox, and making immediate comparison. 1881—Bay-winged sparrows in full song at Lenox, April 16; I returned to Litchfield two days later, but found none till the 20th. The configuration of the country, in connection with such observations, seems to show that many birds follow the coast and rivers, ascend broad valleys sooner than narrow, and thence spread up the slopes and hills, perhaps escaping occasionally through gaps where water-courses nearly meet, from one basin to another. Therefore migrants, especially those hurrying, are comparatively few, or wanting, along high ridges—as exemplified at Litchfield by the scarcity in spring of warblers of the Canadian fauna.

(6) *The effects of elevation on the ornithological calendar.*—Though comparisons of full value should be based upon simultaneous and repeated observations, I venture the conclusions (illustrated by my list of dates, based upon daily search) that Litchfield, as compared with Boston, is, from its elevation, backward in its spring, and in getting the earlier migrants, but that when, after a few hot days, it suddenly gets its summer with wonderful rapidity, it gains from being nearer the southwest sources of migration, and gets its later resident birds—for instance, the wood pewee—sooner.

(7) *Local variations.*—Such are the autumn congregation of over a dozen golden-winged woodpeckers in a flock, and the singing of field sparrows and of redstarts here often with a falling instead of a rising inflection. Such specific variations as red-winged blackbirds, in their spring chorus, congregating commonly in one tree, while the rusty grakles often each take a tree top or limb for himself, and such individual variations as a nuthatch cracking open a hard nut (probably for a maggot) are also curious.

I subjoin here, though the evidence is not complete, the records of a Tennessee warbler, May 6, 1881, and of a black-and-yellow warbler nesting. Martins, a gentleman here tells me, kill interlopers of their own species, cracking the skull. —*Amer. Naturalist.*

* Before remarking on migrations here, I append the following dates of arrival: March 12, blue birds (in numbers; 15, song sparrow, *snow bird*, fox sparrow, red-winged blackbird and rusty grakle; '25, meadow lark; April 1, the first pewee; 3, horned larks; 9, downy woodpecker; 20, white-breasted swallow, Savannah sparrow, bay-winged sparrow, cow-bird, and kingfisher; 22, hermit thrush; 23, red-poll warbler, martins, swamp, field, and chipping sparrows, yellow-bellied woodpecker (among hemlocks), and golden-crowned kinglet (absent latterly in winter); 24, ruby-crowned kinglet (singing), yellow-rumped warbler, barn swallow, solitary vireo, and purple finch, and goldfinch (after a long absence; 28, brown thrush, creeping warbler (*Mniotilta*), white-throated sparrow (earlier?), and towhee; May 1, orchard flycatcher (*Empidonax minimus* —the first appeared April 27); 3, Swainson's thrush (a pair in a pasture(!) by a rill), cat-bird, oven-bird, yellow warbler, and king-bird; 5, house wren; 6, Wilson's thrush and redstart; 7, warbling vireo; 8, chestnut-sided warbler, Maryland yellow throat, Baltimore oriole (abundant next morning), "night hawk" (in the village), and wood thrush (probably); 9, Nashville warbler, "blue yellow-back," etc., red-eyed vireo, rose breasted grosbeak, bobolink and Traill's flycatcher; 10, wood pewee and whippoorwill; 12, cedar-birds; 13, yellow-throated vireo and black-and-yellow warbler (or earlier); 14, scarlet tanager; 15, black-billed cuckoo, and so on. Blue birds had eggs in the last week of April; robins and pewees began to lay about May 1st.

STORING CABBAGES.

IF there were any winter cabbages in this neighborhood worth mentioning, it might be useful to describe the method of keeping them for winter use; perhaps the frost has not been so destructive in other places, however, and the following directions may be applied in more favored regions. Select a place for the winter bed sheltered from the north and west, and well drained; if convenient to the barn and house, all the better. Plow and roll the land till it is mellow and free from lumps, and let the roller pass over it after the last plowing. Then plow a back furrow with the small plow along the middle of the piece. The cabbages are stripped of their coarse leaves rapidly in the field before pulling them, they are then pulled and thrown, stump and all, into tip carts, and dumped conveniently near the open furrows above named, part on each side of the ridge; they are then picked up and planted in the furrows as thickly as they will stand, and when the furrows are full, the earth is to be thrown up to the roots by another bout with the plow; if the cabbage heads are very large, it will be needful to make two bouts with the plow before setting a second row, otherwise one will answer; after the cabbages have all been heeled in after this manner, go all around the bed twice with the plow, so as to throw up the earth well and leave a good furrow to drain off surface water; finally dress out the furrow and banking with a shovel, so as to give a free outlet to water. If the weather should be warm after bedding them, the cabbages may be left uncovered, but if it freezes much, they should be at once covered with a few leaves or bog hay, increasing the covering as cold weather gets severe; the final covering should be six inches of leaves and hay well settled; this will keep the cabbages all winter if desired, or they can be taken out in fine weather at any time in winter for use. When taking them out, strip off the covering and cut off the stumps with a hatchet, throwing the heads into barrels, to be trimmed indoors, if the weather is frosty. They can be taken out in very cold weather if managed well.

In a long continued thaw, cabbages covered too deeply will sometimes heat and rot. It is needful to watch them in such weather and strip off the covering for a day if needed, replacing it before it gets cold again. The proper time to bed cabbages is the first week or ten days of November, or any dry day after then, when the heads are not frozen; if they freeze in the field, wait till they thaw before handling them. The coarse leaves taken off in winter when trimming them for market, are keenly relished by cows and hens. The stumps left in the bed should be covered up with litter after cutting the heads; the covering may be removed about April 1st, when many stumps will throw up sprouts, always acceptable as the earliest cabbage greens of the season.—*W. D. Philbrick, in N. E. Farmer.*

[NEW ENGLAND FARMER.]

THE CULTURE OF TUBEROSES.

IF, as seems to be the case, the farmer's wife is obliged to endure the monotony of farm life, either in the management or execution of household duties, it should not only be allowed, but the good housewife should be indulged and assisted in the cultivation of these products of nature, that some one has denominated God's smiles—the beautiful flowers.

There are very many of the most beautiful specimens of the floral world that have been looked upon as beyond the reach of the average farmer's wife and daughter, simply because heretofore, and perhaps almost exclusively, they have been confined to green-houses or to the handling of professional florists. Such is the case with the tuberose, a plant of such exquisite bloom and such rich perfume. When the beautiful fragrance of this plant, as it has appeared in the bouquet or floral offering of the professional, has been once tested, there comes a sigh and desire for a still greater and more extensive enjoyment of the luxury. In this there is no difficulty, as it is the purpose of this article to show.

In the first place the plant grows from a bulb, and these can easily be procured in a small quantity for starting, and then the stock can be increased at pleasure. The bulbs increase by enlarged growth from the parent bulb, and three years are required to bring them to bloom, after which the original bulb is of no account, unless to increase the stock, which is hardly desirable, since, with a fair share of care, the developing bulbs will increase the stock with sufficient rapidity.

So far as soil is concerned, any good garden soil that will grow good vegetables will grow tuberoses. It is not necessary that they should be petted and receive all the care and attention that professional florists would claim, because, if kept as they should be, where it is warm and the bulbs slightly moistened for a little time before the soil can be worked, as soon as danger from frost is passed and the soil can be brought into a good mellow condition, operations may be commenced; and if the soil is not of the desired fertility, let any good manure be plowed into the soil and well incorporated with it. Then let the ground be thoroughly worked over and made smooth, and a little furrow marked with the corner of a hoe to the depth of one and a half to two inches, or sufficiently deep to receive the bulbs, which should all be separated, and planted, as near as can be judged, according to the age. It is not desirable to occupy a large amount of space; they may be planted no more than two or three inches apart in the row, and the rows not more than six or eight inches apart, or what is sufficient for the passage of the garden hoe between them. When set, the earth may be hauled carefully over them, and the work of planting is accomplished. Thus the labor of planting is in reality no more than would be necessary to plant potato onions; neither is the after care any more; as they come up, they require occasional hoeing, that the soil may be kept loose, and to prevent the growth of weeds, and in return for this little amount of labor, the laborer will be rewarded with spikes containing from twenty-five to thirty-five blossoms each, with a growth of young bulbs besides. But the care does not quite end here; the plant is extremely susceptible to chilling cold, and the tubers are easily destroyed, therefore it is necessary that, before any severe frosts in the fall, the tubers should be lifted and placed in some warm locality to dry and cure for winter keeping. If some have failed to bloom, that give promise to, such may be lifted and placed in a box of earth and brought into the dwelling, where they will continue to bloom, even into cold weather. When the bulbs are sufficiently dried, they should be stored in a dry, warm place, beyond the possibility of being chilled, and kept until spring. Of course it is desirable, in order to have flowering bulbs each year, to keep a stock of all ages of growth, and then the thing is accomplished.

To show that it is not difficult to make the little bulbs grow, it may be said that last spring, after the family of the writer had planted 3,000 bulbs, they left a number of hundred of the smaller specimens of the first year's growth, and it occurred to us that a little experiment might be tried touching the difficulty or ease of growing tuberoses; so a small bed was well raked over, and the little bulbs evenly spread over the surface, and lightly covered with loose soil. The result was that they came up thickly, and with a little hand pulling of weeds, did nicely, and this fall were lifted to add to the stock of bulbs of two years' growth. So farmers' wives or daughters need not suppose that the skill of producing tuberoses is confined exclusively to professional florists, for it is a thing which they may possess, if they are so disposed.

WILLIAM H. YEOMANS.

Columbia, Conn., 1881.

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